INSTITUTE OF NEUROLOGY
The
ROCKEFELLER
MEDICAL LIBRARY

7 JAN 1965

Shelf 9.

PRESENTED TO
The Medical Library
QUEEN SQUARE, BLOOMSBURY, LON

ON THE

REPARATIVE PROCESS

IN

HUMAN TENDONS.

Digitized by the Internet Archive
in 2014

https://archive.org/details/b21270235

To the Medical Library
of the National Hospital for the Paralysed
and Epileptic.
From the Author
Wm Adams
7961 10 a 1850

ON THE

REPARATIVE PROCESS

IN

HUMAN TENDONS

AFTER

SUBCUTANEOUS DIVISION FOR THE CURE OF DEFORMITIES;

WITH AN ACCOUNT OF THE APPEARANCES PRESENTED IN FIFTEEN POST-MORTEM EXAMINATIONS IN THE HUMAN SUBJECT;

ALSO

A Series of Experiments on Rabbits, and a Résumé of the English and Foreign Literature of the Subject.

Illustrated by

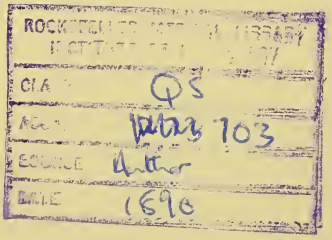
SEVEN LITHOGRAPH PLATES AND A SERIES OF WOODCUTS.

BY

WILLIAM ADAMS, F.R.C.S.,

SURGEON TO THE ROYAL ORTHOPÆDIC AND GREAT NORTHERN HOSPITALS; LECTURER ON SURGERY AT THE GROSVENOR PLACE SCHOOL OF MEDICIN E; LATE DEMONSTRATOR OF MORBID ANATOMY AT ST. THOMAS'S HOSPITAL, ETC.

LONDON:
JOHN CHURCHILL, NEW BURLINGTON STREET.
MDCCCLX.



PRINTED BY J. E. ADLARD,
BARTHOLOMEW CLOSE.

PRESENTED TO
The Medical Library
QUEEN SQUARE, BLOOMSBURY

TABLE OF CONTENTS.

PLATES.

SEVEN LITHOGRAPH PLATES, REPRESENTING THE APPEARANCES IN TEN CASES IN WHICH THE TENDONS HAD BEEN DIVIDED AT DIFFERENT PERIODS, FROM FOUR DAYS TO THREE YEARS PREVIOUS TO THE DEATH OF THE PATIENT, OR AMPUTATION OF THE LIMB.

In two plates the microscopical appearances of the new connective tissue at different periods, and its mode of junction with the old tendon, are exhibited.

PAGE

PREFACE vii

PART I.

ON THE REPARATIVE PROCESS IN HUMAN TENDONS AFTER SUBCUTANEOUS DIVISION FOR THE CURE OF DEFORMITIES.

CHAPTER I.

INTRODUCTORY REMARKS 1

CHAPTER II.

CASES AND POST-MORTEM EXAMINATIONS . . 6

CHAPTER III.

GENERAL SUMMARY OF THE REPARATIVE PROCESS . 58

CHAPTER IV.

PAGE

CIRCUMSTANCES WHICH MAY INTERFERE WITH THE PERFECTION OF THE REPARATIVE PROCESS, OR ENTIRELY PREVENT IT, SO THAT NON-UNION OF THE DIVIDED TENDON MAY RESULT 70

CHAPTER V.

CONCLUSIONS 78

PART II.

A SERIES OF EXPERIMENTS ILLUSTRATING THE REPARATIVE PROCESS IN THE TENDONS OF RABBITS AFTER DIVISION BY SUBCUTANEOUS AND OPEN WOUND.

CHAPTER I.

INTRODUCTORY REMARKS 87

CHAPTER II.

DETAILS OF EXPERIMENTS 91

CHAPTER III.

GENERAL SUMMARY OF THE REPARATIVE PROCESS . 108

A Series of Woodcuts illustrating the Reparative Process in Eight of the above Experiments.

APPENDIX.

A RÉSUMÉ OF THE ENGLISH AND FOREIGN LITERATURE OF THE REPARATIVE PROCESS IN TENDONS AFTER DIVISION, EITHER BY SUBCUTANEOUS OR OPEN WOUND . . 123

PREFACE.

The subcutaneous division of tendons for the cure of deformities is now a well-established surgical operation, and since it was first performed by Stromeyer, in 1831, experience has only tended to confirm our confidence in the operation as one free from all risk of local inflammation, and from any danger or fear of harm to the patient, when the conditions necessary to its successful performance are fulfilled. Stromeyer freely and generously admits that in the performance of this operation he was guided by the principles laid down by Delpech in 1828 (see Appendix, Delpech); but it ought especially to be borne in mind that the general law upon which the safety of all subcutaneous operations depends, and upon which, therefore, the whole practice of subcutaneous surgery is based,[1] was first established by the greatest of English surgeons and physiologists, John Hunter, and published by him in the year 1794, in his 'Treatise on the Blood, Inflammation, and Gun-shot wounds.' Hunter pointed out as a great fundamental principle, in reference to the healing of wounds, the difference between those two forms of injuries, of which one is subcutaneous, and the other open to the air, and upon this basis adopted a classification of injuries to sound parts into two divisions. Of these

[1] See 'A Sketch of the Principles and Practice of Subcutaneous Surgery,' in which this subject is fully discussed, by W. Adams, London, 1857.

he observes: "The injuries of the first division, in which the parts do not communicate externally, seldom inflame, while those of the second commonly both inflame and suppurate."[1]

Here, then, is the law of the reparative process in these two great classes of injuries, and until the division of tendons was adopted by Stromeyer according to this law, by making a very small puncture at a distance from the tendon to be divided, and completely excluding the air from the divided parts, the risk of suppurative inflammation was known to be so great that the operation had only been attempted in a few instances, and then had been followed by very serious consequences.

That John Hunter practically applied this principle, in reference to tenotomy, is also established by the fact placed on record, that about the year 1767 he divided the Achilles tendons in dogs, the ass, and deer, subcutaneously, for the purpose of investigating the nature of the reparative process;[2] and the tendons thus divided by Hunter, by subcutaneous section, are preserved in the Museum of the Royal College of Surgeons. (See Appendix, Hunter.)

Often as such experiments have been repeated since the time of Hunter, it may appear somewhat remarkable that even at the present day opinions differ very widely both with respect to the actual phenomena observed during the reparative process, and also as to the general pathology of the reparative process in tendons

[1] See 'Hunter's Works,' by J. F. Palmer, vol. iii, p. 240, 1837.

[2] 'Life of John Hunter,' by Drewry Ottley, prefixed to Palmer's edition of Hunter's works, London, 1837.

after division. Compare, for instance, the accounts given by Paget, 1849; Gerstaecker, 1851; Thierfelder, 1852; and Boner, 1854 (see Appendix). The whole subject must, therefore, be considered as still open for further investigation.

On this account, and in the hope of adding something to our knowledge of this most interesting physiological process, I have been induced now to publish in a connected form such observations as I have been enabled to make in reference to this subject, by a series of experiments which I performed on sixteen rabbits, in the year 1855, and also by the post-mortem examinations, in the recent state, of fifteen cases in the human subject, in which subcutaneous tenotomy had been performed, at periods varying from four days to three years previously—as well as by the examination of several other specimens which had been preserved in spirits. All the facts, therefore, which have come under my observation in connexion with this subject are here recorded.

In the 'Transactions' of the Medical and Chirurgical, and of the Pathological Societies, papers on the reparative process in tendons in animals and also in the human subject, communicated by me, have already been published, and in these papers are embodied the general results and conclusions given in the present work, but the facts from which these conclusions have been deduced, *i.e.*,—the details of the experiments on rabbits, and of the post-mortem examinations in the human subject—were published only in abstract, to suit the space allotted to them in the works

referred to.[1] I have now, therefore, published these details in full, in the hope that they may be found useful to those who may hereafter have the opportunity of investigating this subject. It seemed to me, moreover, that these papers served each one to add to the value of the other, and that taken together they might be considered as illustrating the general subject of the reparative process in tendons after division by subcutaneous and open wound.

I have now also added a series of seven lithograph plates, selected from the drawings which were exhibited to the Medical and Chirurgical Society, but none of which were published by the Society in their 'Transactions.' These drawings were for the most part made by Mr. G. Ford, either at the time of the post-mortem examinations, or subsequently from the specimens removed; in a few instances only from sketches made by myself, when circumstances rendered it impossible for me to remove the specimens, and I have to express my obligations to Mr. Ford for the extreme care and attention to detail with which the drawings

[1] A Series of Experiments illustrating the Reparative Process in the Tendons of Rabbits, after Division by Subcutaneous and Open Wounds, 'Trans. Pathological Society of London,' vol. vi, 1855.

A Dissected Specimen of Non-congenital Club-foot — Talipes equino-varus of Paralytic origin, in which Relapse of the Deformity had taken place after several operations, 'Trans. Path. Society,' vol. viii, 1857.

On the Reparative Process in Human Tendons after Subcutaneous Division for the Cure of Deformities, 'Trans. Medical and Chirurgical Society,' vol. xlvii, London, 1859.

and the plates now published have been executed. The drawings of the microscopic appearances were selected from a series drawn by myself. The drawing from which Plate V has been taken was made by Mr. Fairland with the greatest accuracy, from my dissection of the leg. This plate has already been published in the 'Trans. Path. Soc.,' vol. viii, 1857.

In order to render the present work still more complete, I have added as an appendix a *résumé* of the opinions entertained by the principal writers—both English and foreign—on the subject of the reparative process in tendons after division by subcutaneous and open wound. Many of these are based upon experiments on animals, which are also referred to. In the foreign literature of the subject no authors have been omitted whose works were accessible, or contained in our public libraries, and for the extracts from these books I am indebted to my friend, Dr. H. Dick.

It is somewhat remarkable that we have not been able to find in any of the foreign authors the account of a single post-mortem examination after tenotomy in the human subject.

PRESENTED TO

Fig 1

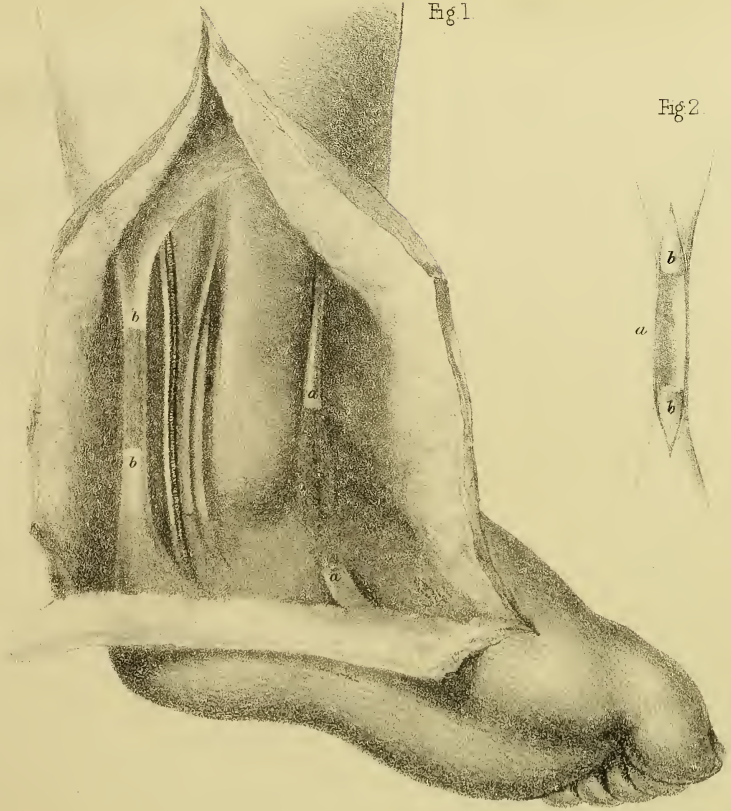
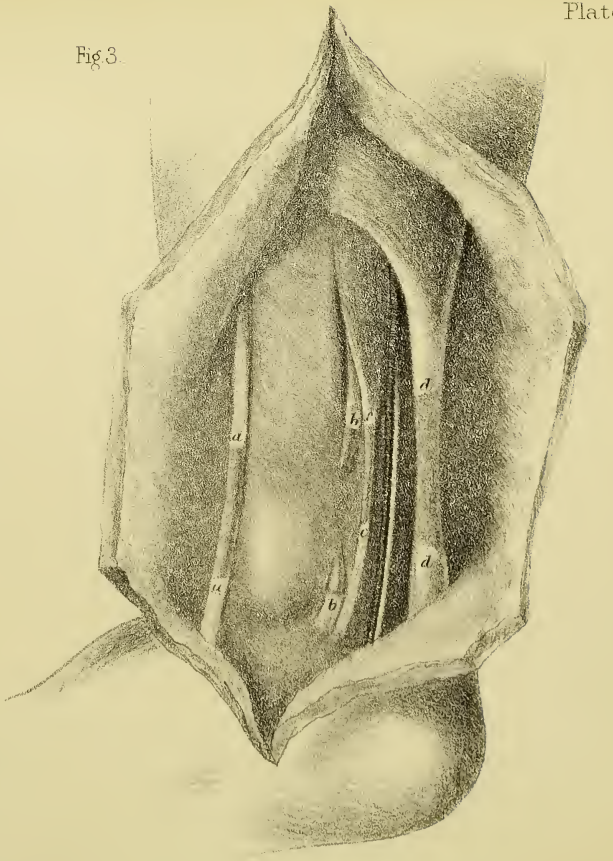


Fig 2

Fig 3



C.H Ford after W.A

W West imp

DESCRIPTION OF PLATE I.

FOUR DAYS AFTER OPERATION.—CASE 1, FIGS. 1 AND 2. CONGENITAL VARUS. AND ELEVEN DAYS AFTER OPERATION.—CASE 2, FIG. 3. CONGENITAL VARUS.—FIGURES DRAWN NATURAL SIZE.

Fig. 1.—Tibialis anticus and tendo Achillis divided.

Divided extremities of the Tibialis anticus, a, a, one inch apart, and not distinctly connected by the sheath, as in the tendo Achillis. In the track of the tendon was a small quantity of black coagulum; cut ends of the tendon square, abrupt and unaltered.

Divided extremities of the tendo Achillis, b, b, three quarters of an inch apart, but still connected by the cellular sheath of the tendon, which had been but little injured.

Fig. 2.—Diagram sketch of the tendo Achillis in fig. 1, with the sheath laid open, showing its tubular form *a*, and its influence in connecting the divided extremities of the tendon *b, b.*

ELEVEN DAYS AFTER OPERATION.—CASE 2. CONGENITAL VARUS.

Fig. 3.—Tibialis anticus and posticus; Flexor longus digitorum; and tendo Achillis divided.

Divided extremities of the Tibialis anticus, a, a, seven eighths of an inch apart, but connected by a solid and cylindrical bond of new material.

Divided extremities of the Tibialis posticus, b, b, seven eighths of an inch apart, and not united by intermediate substance, but connected with each of the cut extremities of this tendon is a small portion of new material, a quarter of an inch in length; that connected with the lower extremity is of a conical form, terminating above in a point, and that connected with the upper extremity of a cylindrical form, terminating below by an abrupt and square extremity.

It seemed very doubtful whether union would ever have taken place between the divided extremities of this tendon; their permanent connexion with the sheath, as in case 12 (see Plate V), appearing more probable.

Divided extremities of the Flexor longus digitorum, c, c, seven eighths of an inch apart, but directly connected by a thin band of fibrous tissue like sheath, or areolar tissue in an infiltrated and succulent condition.

Divided extremities of the tendo Achillis, d, d, seven eighths of an inch apart, but connected by a solid bond of union, equal in diameter to that of the tendon, but of a soft and gelatinous consistence.

DESCRIPTION OF PLATE II.

SIXTEEN, TWENTY-THREE, AND THIRTY DAYS AFTER OPERATION.—CASE 3. CONGENITAL VARUS; BOTH FEET FROM SAME CASE.—FIGURES DRAWN NATURAL SIZE.

Fig. 1 *represents the foot at the end of the first stage of treatment, viz., when, after the division of the Tibiales anticus and posticus tendons, it has been brought from the position of talipes varus into that of talipes equinus; and fig.* 2, *from the opposite leg of the same infant, represents the foot at the end of the second stage of treatment, viz., when, after the division of the tendo Achillis, it has been brought from the position of talipes equinus into a natural position with respect to the leg, or at a right angle with the leg, the deformity now being cured. Figures drawn natural size.*

TWENTY-THREE DAYS AFTER OPERATION.

Fig. 1.—Tibiales anticus and posticus tendons of the left foot divided.

Divided extremities of the Tibialis anticus, a, a, three quarters of an inch apart, but connected by a solid cylindrical bond of new material, equal in diameter and bulk to the extremities of the tendon it serves to connect.

Divided extremities of the Tibialis posticus, b, b, half an inch apart, but connected by a solid cylindrical bond of new material.

SIXTEEN DAYS AND THIRTY DAYS AFTER OPERATION.

Figs. 2 *and* 2 *a,* from same case as fig. 1.—Tendo Achillis and Tibialis anticus tendon of the right foot divided.

Fig. 2.—*Divided extremities of the tendo Achillis, c, c,* sixteen days after operation, rather more than half an inch apart, but connected by a tough cylindrical bond of union, equal in diameter and bulk to the tendon it connects.

Fig. 2 *a, represents a longitudinal section of the same tendo Achillis.* The divided extremities of the tendon, *a, a,* are seen rather more than half an inch apart, but connected by a solid bond of new material, or new tendon, imbedded in the lower part of which is a small clot of blood. The cut extremities of the old tendon retain their abrupt and square outline, and are readily distinguishable from the new tendon, with which, however, they are firmly connected by a very fine dovetailing arrangement of old and new tissue. The microscopical appearances from this specimen are represented in Plate VI, figs. 1 and 1 *a.*

THIRTY DAYS AFTER OPERATION.

Fig. 2.—The Tibialis anticus divided.

Divided extremities of the Tibialis anticus, a, a, nearly three quarters of an inch apart, but connected by a cylindrical bond of new tendinous structure, very nearly equal in diameter and bulk to the extremities of the tendon it served to connect.

The posterior Tibial tendon had not been divided in this case, though the operation had been attempted; and externally the tendon presented some appearances, leading at first to the supposition that it had been divided. (See notes of case.)

Fig. 2.

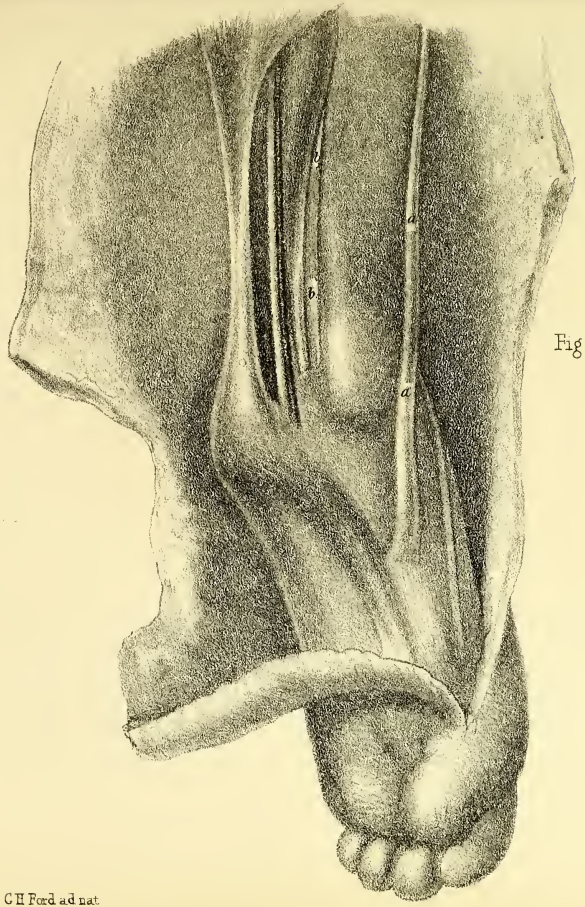


Fig 1

Fig. 2a.



C H Ford ad nat.

W West imp

...TAL FOR THE PARA...
PRESENTED TO
...EEN SQUARE, BLOOMSBURY, LON...

PRESENTED TO

Fig 1.



Fig 2



Fig 3.



Fig 4



Fig 5.



DESCRIPTION OF PLATE III.

EXHIBITING THE APPEARANCE OF THE NEWLY FORMED CONNECTIVE TISSUE, OR NEW TENDON, AT PERIODS VARYING FROM THREE MONTHS TO THREE YEARS AFTER THE SUBCUTANEOUS DIVISION OF THE TENDO ACHILLES.—TENDONS DRAWN THE NATURAL SIZE.

Fig. 1.—TENDO ACHILLIS THREE MONTHS AFTER DIVISION.—CASE 7.

Divided extremities of the tendon, a, a, three quarters of an inch apart, but firmly connected by a tough and close-textured, solid bond of new material, or new tendon, equal in bulk and thickness to the tendon it served to reunite. The new tendon had a slightly striated appearance, with vessels running longitudinally through its texture. The process of dovetailing at the seat of junction of the new with the old tendon; the new tissue overlapping and surrounding the upper extremity of the old tendon; a slight bulbous enlargement of the old tendon, especially in the lower extremity; and some want of definition along the deep border of the new tendon from adhesions, are points well shown in the drawing.

Fig. 2.—TENDO ACHILLIS SEVEN MONTHS AFTER DIVISION.—CASE 9.

Divided extremities of the tendon, a, a, rather more than one inch apart, but firmly connected, as in fig. 1, by newly formed tendinous structure, equal in bulk and thickness to the tendon it served to reunite. The junction of the new with the old tendon by a fine dovetailing process; a slightly striated appearance of the new tissue; and some want of definition along its deep border, are well shown in the drawing.

Fig. 3.—A TENDO ACHILLIS WHICH HAD BEEN DIVIDED THREE TIMES, AT PERIODS OF ABOUT FOUR MONTHS, SEVEN MONTHS, AND ONE YEAR PREVIOUS TO DEATH.—CASE 10.

Divided extremities of the tendon, a, a, an inch and a half apart, but in the intermediate space are two detached portions of old tendon, *b, b,* measuring together about half an inch in length, intimately united, by a fine dovetailing process at their margins, with the newly formed connective tissue, or new tendon which in all respects resembled the new tendinous structure described in the other specimens, except in the central portion (probably the seat of the last division), which had a more ruddy tinge, and in its substance was imbedded the remains of a small clot of blood, *c.*

Figs. 4 *and* 5.—TWO ACHILLES TENDONS FROM THE SAME CASE, THREE YEARS AFTER DIVISION.—CASE 13.

The patient from whose body these tendons were removed—a lady, æt. 42 years—had been the subject of paralysis of both legs from the age of five years, and the limbs were in an extremely atrophied condition; hence the very small size of the tendons. (See Plate VII, fig. 3 and fig. 3 *a,* for the microscopical appearance of the new tendon in this case; and fig. 4 and fig. 4 *a,* for the appearances of the structural degeneration of the old tendon.)

Divided extremities of the tendon a, a, both in figs. 4 *and* 5, about an inch and a quarter apart, but firmly connected by new tendinous structure, equal in bulk and thickness to the tendons it served to reunite. The junction of the new with the old tendon, by a fine dovetailing process, was still distinct; and this together with the striated appearance of the new tendon, and its want of definition along the deep border, in consequence of adhesions, are well represented in the drawings. In fig. 5 also, the new tendinous tissue is seen extending beyond, and as it were ensheathing the cut extremities of the old tendon.

DESCRIPTION OF PLATE IV.

DISSECTION OF A LEG, EXHIBITING THE APPEARANCES PRESENTED BY THE TENDO ACHILLIS A YEAR AND A HALF AFTER ITS SUBCUTANEOUS DIVISION. CASE 11.—FIGURE DRAWN NATURAL SIZE.

Divided extremities of the tendon, a, a, two inches and a quarter apart, but connected by newly formed tendinous structure, equal in bulk and thickness to the tendon it served to reunite. The junction of the new with the old tendon by a process of fine dovetailing—the new material, easily recognised by its translucency in the recent state, being inserted between the split fibres of the old tendon, which still preserved their opaque, pearly lustre—was very distinct, and has been well represented. The structure of the new tendon did not present a longitudinally striated appearance, as seen in several specimens, but was traversed by some opaque, white, glistening fibres, passing obliquely through it; this appearance, together with the loss of linear definition along its deep border, in consequence of adhesions, are also well shown.

This specimen exhibited the greatest length of new tendon I have seen in the human subject; and as the new tissue presented the microscopic characters of well-formed tendon (see Plate VII, figs. 2 and 2 *a*), it may doubtless be regarded as affording a most perfect example of the regeneration of tendinous structure.

It is also important to remark in this case, that whilst the new tendon remained as a permanent tissue, elongating the tendo Achillis to the extent of two inches and a quarter, reproduction of the deformity, viz., talipes equinus, took place to a considerable extent, some months previous to the amputation of the leg, which was performed by Mr. Curling, for recurrent fibroid tumour connected with the periosteum of the tibia, &c., and involving the muscles of the calf. The elevation of the heel is represented in the drawing, but, from want of space to insert the foot, the general appearance of the deformity could not be shown.

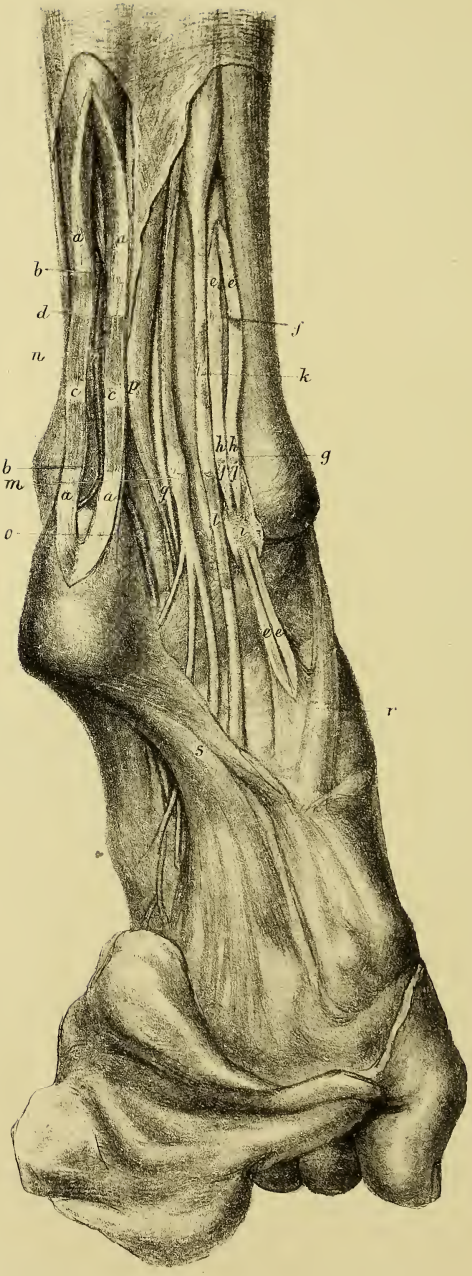


C.H.Ford ad nat.

W.West imp.

PRESENTED TO

PRESENTED TO


a
a
b
d
n
c
c
p
b
m
a
a
o
e
e
f
k
h
h
g
i
i
q
l
l
r
r
s

DESCRIPTION OF PLATE V.

THIS PLATE ILLUSTRATES THE REPARATIVE PROCESS IN SEVERAL TENDONS WHICH HAD BEEN DIVIDED AND RE-DIVIDED AT VARIOUS AND UNCERTAIN PERIODS, THE LAST OPERATION HAVING BEEN PERFORMED TWO YEARS BEFORE THE DEATH OF THE PATIENT. FROM A CASE OF NON-CONGENITAL TALIPES EQUINO-VARUS OF PARALYTIC ORIGIN. RELAPSE OF THE DEFORMITY, AS REPRESENTED IN THE PLATE, HAD TAKEN PLACE SOME TIME PREVIOUS TO DEATH.

a, a. Tendo Achillis longitudinally divided, exhibiting the extent and relations of the new tendinous material, as follows: *b, b.* The upper and lower terminations of the old tendon, between which new tendon is seen, intermixed with a small quantity of old tendon, several divisions having been made within this distance. *c.* An isolated portion of old tendon, presenting a white glistening appearance, with new tendon above and below it. *d.* A transverse line apparently indicating where a division had been performed through the new tendon.

e, e. The Tibialis posticus tendon longitudinally divided. *f.* A wedge-shaped portion of new tendon, where an imperfect division had been made. On the corresponding half of the tendon in this situation there is only a trace of new tendon, the old tendinous fibres being distinctly continuous in most parts. *g* indicates the situation in which this tendon has been divided behind the malleolus; and on same level, it will also be seen, the flexor longus has been divided. *h, h.* The upper and lower extremities of the divided posterior tibial tendon. *i.* The anterior wall of the sheath of the posterior tibial tendon, which has been laid open, and to which the divided extremities of this tendon are adherent through the medium of a small quantity of new tendinous tissue, formed in connexion with them. *j* indicates the new tissue connected with the upper extremity of this tendon.

k. A portion of new tendon, seven eighths of an inch in length, formed between the divided extremities of the tendon of the flexor longus digitorum muscle, which had evidently been divided above the malleolus simultaneously with the partial division of the posterior tibial tendon in this situation. *l.* A similar portion of new tendon, one inch and an eighth in length, between the divided extremities of the flexor longus tendon, behind the malleolus. This operation had evidently been performed at the same time as the division of the posterior tibial tendon behind the malleolus. Between these two long portions of new tendon, an isolated oat-shaped portion of old tendon is seen.

m. The posterior tibial nerve enlarged to about twice its normal size, probably in consequence of having been divided or wounded when the posterior tibial and long flexor tendons were divided.

n. The peroneal artery occupying its ordinary position, but much enlarged, to compensate for the absence of the posterior tibial artery.

o. Continuation of the peroneal artery, winding round the inner side of the os calcis to gain the sole of the foot, and supply the place of the posterior tibial.

p. An accessory muscular slip connected above with the flexor longus pollicis and, by its tendon in the sole of the foot, with the tendon of the flexor longus digitorum.

q. The tendon of the flexor longus pollicis crossed by the accessory muscle, *p.*

r. The tendon of the tibialis anticus muscle.

s. The plantar fascia.

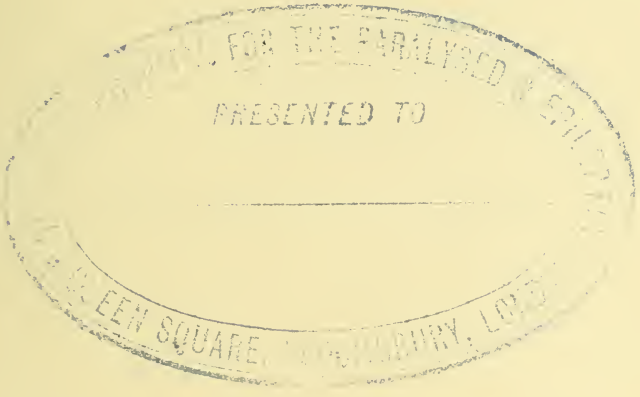

FOR THE PARALYSED &
PRESENTED TO
EEN SQUARE

Fig.1. a b

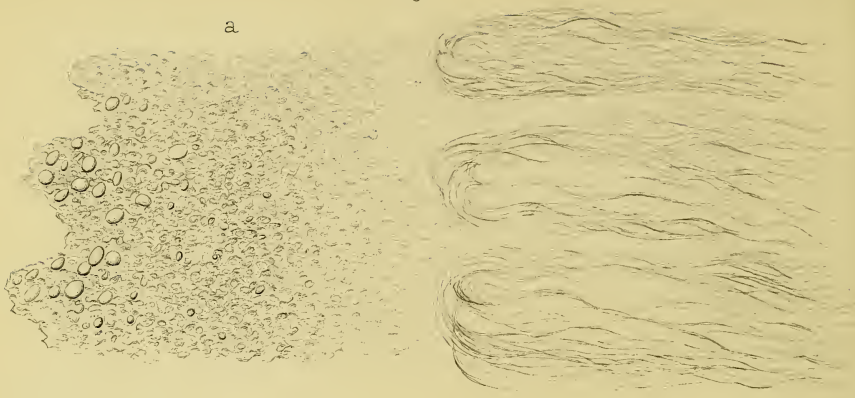
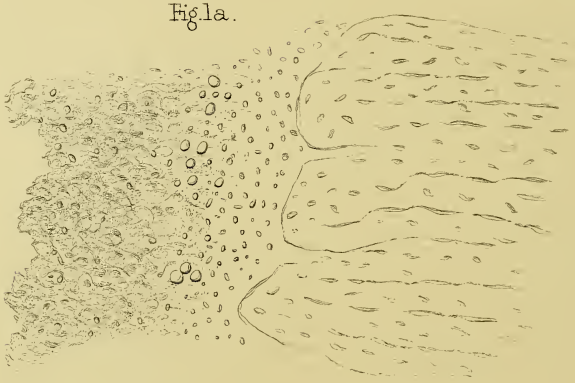


Fig.1a.



a Fig.2. b



Fig.2a.



DESCRIPTION OF PLATE VI.

EXHIBITING THE MICROSCOPICAL APPEARANCES AT THE SEAT OF OPERATION IN HUMAN TENDONS SIXTEEN AND TWENTY-THREE DAYS AFTER SUBCUTANEOUS DIVISION. FIGS. 1 *a* AND 2 *a* REPRESENT THE APPEARANCES OF FIGS. 1 AND 2 AFTER THE ADDITION OF ACETIC ACID.

Fig. 1.—Tendo Achillis of an infant sixteen days after division, from case 3, showing the microscopical appearances of the new connective tissue *a*, and of the old tendon, *b*, at the seat of division. Specimen taken from the central portion, so that the fibro-cellular tissue of the sheath which circumferentially connected the new with the old tissue was not included.

a. *New connective tissue*, presenting a nebulous, granular, and obscurely nucleated appearance, studded with molecules and larger globules of oil. This tissue was much clearer near to the divided extremity of the old tendon, where it exhibited more of a nucleated blastematous appearance.

b. *Divided extremity of the old tendon*, lower end, showing a coarse separation of the structure of the old tendon into obtusely rounded bundles of fibres, between which the new material is inserted.

Fig. 1 *a*. *The same after the addition of acetic acid*, by which the nucleated character of the new connective tissue is brought more clearly into view. The clearness of the new tissue close to the cut extremity of the old tendon, and the abundance of small rounded and oval nuclei, without any disposition to a linear arrangement at this part, are well shown. The acetic acid, also, has the effect in the old tendon of bringing into view the arrangement of elongated nuclei in parallel linear series; and the bundles of fibres of the old tendon now appear more angular, and of an irregular square outline at their cut extremities.

Fig. 2.—Posterior tibial tendon of an infant, twenty-three days after division, from the same child as the preceding (case 3), showing the microscopical appearances of the new connective tissue, *a*, and of the old tendon, *b*, at the seat of division.

a. *New connective tissue*, approaching in its structural characters the appearance of well-formed tendon; it exhibits a delicate but distinctly fibrillated appearance, but its margins would not split or fray out into separable fibres: when compressed under the microscope, its edges resembled the jagged margins of a bit of torn membrane—an appearance well shown in the drawing. The new tissue was traversed by numerous blood-vessels, which ran obliquely through its substance, the smallest branches only taking a longitudinal direction.

b. *Divided extremity of the old tendon*, exhibiting very distinctly, at the line of section, a process of dovetailing of the new with the old tendon, by which they are firmly united.

Fig. 2 *a*. *The same after the addition of acetic acid*, by which elongated nuclei, arranged in parallel linear series, both in the new connective tissue and in the old tendon, are brought into view. The new tissue, therefore, in this specimen approached so closely in its structural arrangement the characters of well-formed tendon as to justify its being described as newly-formed tendinous structure. The nuclei in the new tendon presented a dotted appearance, and, at the junction of the new with the old tendon, small rounded and oval nuclei were scattered without any regularity or disposition to linear arrangement.


PRESENTED TO

Fig 1.

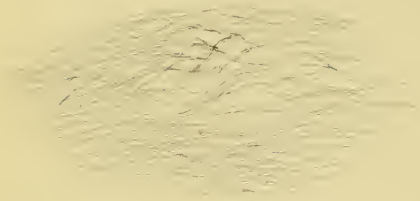


Fig 1a



Fig. 2.

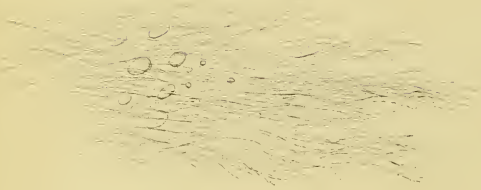


Fig. 2a.

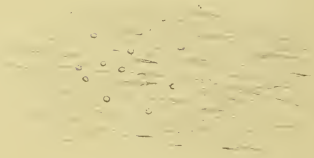


Fig. 3.

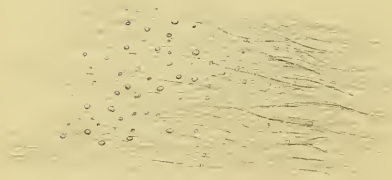


Fig 3a.

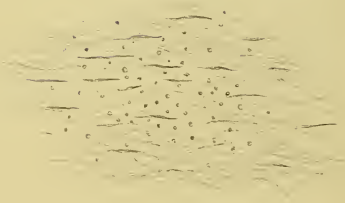


Fig. 4.

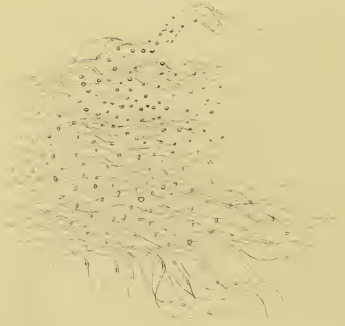


Fig 4a



DESCRIPTION OF PLATE VII.

EXHIBITING THE MICROSCOPICAL APPEARANCES OF THE NEWLY FORMED CONNECTIVE TISSUE, OR NEW TENDON, AT PERIODS OF THREE MONTHS, A YEAR AND A HALF, AND THREE YEARS AFTER THE SUBCUTANEOUS DIVISION OF THE TENDO ACHILLIS. FIGS. 1 *a*, 2 *a*, AND 3 *a*, REPRESENT THE APPEARANCES OF FIGS. 1, 2, AND 3, AFTER THE ADDITION OF ACETIC ACID. FIGS. 4, AND 4 *a*, REPRESENT THE APPEARANCE, BEFORE AND AFTER THE ADDITION OF ACETIC ACID, OF A TENDO ACHILLIS IN A STATE OF FATTY DEGENERATION, FROM THE PARALYTIC LEG OF A PATIENT, FORTY-TWO YEARS OF AGE.

Fig. 1 *represents the appearance of new connective tissue, or new tendon, formed to reunite the tendo Achillis, three months after its division. From the specimen figured in Plate III, fig.* 1.

The distinctly fibrous appearance of the new tissue, easily splitting into separable fibres, and its general resemblance to the structure of old tendon as represented in Plate VI, fig. 1 *b* and fig. 2 *b*, are well shown.

Fig. 1 *a. The same, after the addition of acetic acid*, by which numerous elongated nuclei, arranged end to end in parallel linear series, are brought into view. In its microscopic characters, it will be seen that the new tissue closely resembles the structure of old tendon as represented in Plate VI, fig. 1 *a*, and fig. 2 *a*.

Fig. 2.—*New tendinous structure formed to reunite the tendo Achillis, one year and a half after its division. From the specimen figured in Plate IV, case* 11.

The appearance of separable fibrous tissue is very distinct, and its general resemblance to the structure of the old tendon so close that it would be difficult to distinguish one from the other.

Fig. 2 *a. The same after the addition of acetic acid*, exhibiting the arrangement of elongated nuclei in parallel linear series, as in old tendon; but the acid did not render the new tissue in this instance so clear and translucent as in the cases at an earlier date. The fibrous character of the new tendon remained faintly traceable long after the addition of the acid, and the nuclei were less distinct.

Fig. 3.—*New tendinous structure formed to reunite the tendo Achillis, three years after its division, exhibiting the appearance of separable fibrous tissue, similar to that represented in fig.* 2, *but dotted with minute molecules of oil.*

Fig. 3 *a. The same after the addition of acetic acid*, presenting a shaded

nebulous appearance, with pale and indistinct traces of its fibrous structure, which the strong acid did not render completely transparent, or invisible, as in the specimens of an earlier date. Dark crooked lines, in ill-defined parallel series, appeared in this structure, as if the remains of the elongated nuclei which I have described as existing in parallel linear series in the earlier specimens.

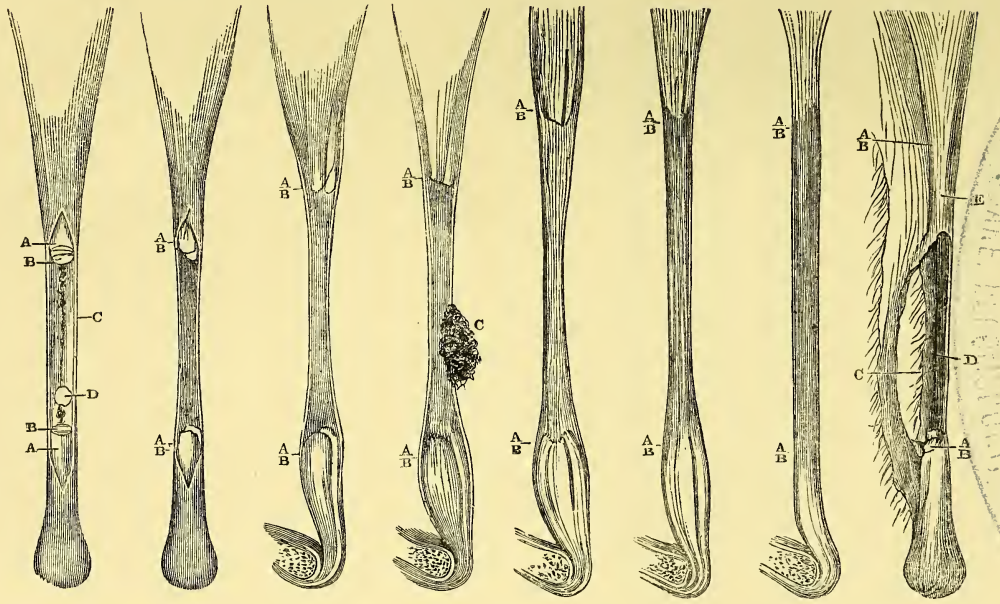
Figs. 4, *and* 4 *a*, *represent the appearances, before and after the addition of acetic acid, of the old tissue of a tendo Achillis in a state of fatty degeneration, from the paralytic leg of a patient, aged* 42. *The same case from which the new tissue represented in figs.* 3, *and* 3 *a, was taken. The external appearances of the atrophied Achilles tendons in this case are represented in Plate III, figs.* 4 *and* 5.

An increased separability of the fibrous structure of the old tendon existed in this case, and is represented in fig. 4, in which the fibres are also shown to be dotted with molecular oil.

After the addition of acetic acid, this tissue presented a shaded nebulous appearance, with indistinct traces of its fibrous structure, and the molecular oil was seen to be very abundant, as represented in fig. 4 *a*.

A series of Engravings illustrating the Reparative Process in eight of the Experiments described.

Plate VIII.



NATIONAL HOSPITAL FOR THE PARALYSED & EPILEPTIC, QUEEN SQUARE, LONDON. PRESENTED TO

AB. AB. Divided extremities of the tendo Achillis and accompanying tendon in the rabbit, retracted after transverse division by subcutaneous section and open wound. Of the latter, fig. 8 is the only example.

Fig. 1.—C. Connecting tubular sheath D. Incision in ditto.

Fig. 4.—C. Clot of blood imbedded in the new connective tissue, and interfering with the reparative process.

Fig. 8.—C. Cutaneous wound, which, though made as a transverse incision, is now seen to be longitudinal. D. Divided edge of sheath not retracted with the tendon, but adherent to the edge of the cutaneous wound, and longitudinal in direction, though it had also been divided transversely.

PRESENTED TO
The Medical Library

PART I.

ON THE

REPARATIVE PROCESS IN HUMAN TENDONS

AFTER

SUBCUTANEOUS DIVISION FOR THE CURE OF DEFORMITIES.

CHAPTER I.

INTRODUCTORY REMARKS.

The reparative process in human tendons after subcutaneous division has not, so far as I am aware, hitherto been investigated in its different stages; obviously from the following causes.

1st. A connected account of the process, from its earliest stages up to its completion, could only be based upon the examination of a large number of specimens; and,

2dly. The opportunities for pursuing this investigation must necessarily be extremely rare; since only those cases would be available for the purpose in which death occurred during the reparative process, from accidental circumstances, or from causes altogether unconnected with the operation, and also those cases in which amputation had

been rendered necessary, as in one of the present instances, from some cause unconnected with the operation of tenotomy. The cases in which death has followed, or amputation been required, from extensive suppuration, sloughing, aneurism, &c., following tenotomy (and such cases have occurred, though very rarely), would be utterly useless for the purpose of this investigation, in consequence of the interference with the healthy process of reparation.

In the absence of observations on the human subject, the reparative process in tendons after division by subcutaneous and open wound has been carefully investigated by experiments on animals, performed by several distinguished Continental and English observers, more especially by Hunter (1767?), Mayo (1827), Von Ammon (1837), Pirogoff (1840), Paget (1849), Gerstaecker (1851), Thierfelder (1852), and Boner (1854). (See Appendix.)

The conclusions arrived at, however, by the above-mentioned authorities as to the nature of the reparative process, and especially in reference to the influence of extravasated blood, inflammatory lymph, and the sheath of the tendon, were so widely different, that in the year 1855 I re-investigated the subject, in a series of experiments performed on sixteen rabbits, dividing the Achilles tendons at different dates, so that thirty-two experiments were made. The parts removed from fourteen of these animals, illustrating the process from the second to the sixty-second day, were exhibited to the Pathological Society, and the results were published in the sixth volume of the society's 'Transactions.'[1] Two other animals lived to the periods of six months and a year.

The details of these experiments are now appended to the present treatise. (See Part II.)

[1] 'Trans. Path. Soc. of London,' vol. vi, 1855.

I will here only observe, that my investigations generally confirmed the account of the process previously given by Mr. Paget, especially with regard to the influence of blood and the inflammatory process in interfering with, rather than assisting, the reparative effort; in this respect, therefore, they were at variance with the opinions of all the other authorities above mentioned. My investigations also confirmed Mr. Paget's observation, with regard to the development of the new connective tissue from a proper reparative material effused for this purpose, and described by Mr. Paget as "nucleated blastema," a material in which the cell-forms do not advance beyond the condition of nuclei, and thus differ from inflammatory lymph, in which fibro-cellular tissue is developed from nucleated cells. The most material point in which my observations differed from those of Mr. Paget was in reference to the influence of the sheath of the tendon, which I found not divided, and generally but very little injured, in the subcutaneous operations. It therefore appeared to me, that in the reparative process the sheath was of primary importance in maintaining a direct connexion between the divided extremities of the tendon. In my experiments, also, it appeared that the new reparative material was infiltrated between the fibrous elements of the sheath, which, therefore, at once formed the matrix for the newly-formed tendon, and also determined its direction and definite form, as described by Thierfelder.

Mr. Paget, on the other hand, completely ignores the influence of the sheath in the reparative process, and after describing the general infiltration and succulency of all the tissues surrounding the tendon, and the subsequent changes which occur in any inflammatory lymph and blood which may be effused, and the manner in which the development

of the nucleated blastema laid down between the separated extremities of the divided tendon appears to proceed, observes that "a single well-designed and cord-like bond of union is thus gradually formed, where at first there had been a uniform, and seemingly purposeless, infiltration of the whole space left by the retraction of the tendon."[1] Mr. Paget also states that, in experiments in which the tendon was divided by an open wound, when the wound through the integuments healed quickly, the case proceeded like one in which the subcutaneous division had been made, and therefore he adduces this in proof "that it is unimportant for the healing of divided Achilles tendons, whether the cellular sheath or covering of the tendon be divided or not."[2] The facts and observations which have led me to a different conclusion on this point, will be specially adverted to in the general description of the reparative process given below.

Valuable as such experiments performed on animals undoubtedly have been, the necessity of investigating the same process in the human subject still remained, and a connexion of nearly ten years with the Royal Orthopædic Hospital has afforded me the opportunity of examining *post mortem* the reparative process in human tendons after subcutaneous division, in nine patients who had been operated upon by myself, one by Mr. Tamplin, and two by my late respected friend and colleague, Mr. Lonsdale. I have also examined after death one of my own cases in private practice. These patients all died from various causes unconnected with the operation, at periods varying from four days to three years after the division of the tendons. I am also indebted to Mr. Erichsen and Mr.

[1] 'Lectures on Surgical Pathology,' vol. i, p. 269. London, 1853.
[2] Ibid., p. 266.

Curling for the opportunity of examining two valuable cases, one after death, and the other after amputation. The details of Mr. Erichsen's case have already been published, together with a lithographed plate of the appearances presented in the 'Transactions of the Pathological Society,' and this plate is now included in the present series.[1] (See Plate V.)

I have therefore examined, in the recent state, fifteen cases in which subcutaneous tenotomy had been performed, at periods varying from four days to three years previously, and from twelve of these either the specimens or drawings—in ten cases the specimens—were presented to the Medical and Chirurgical Society, when the results of my observations were first communicated to that Society in a paper on "The Reparative Process in Human Tendons," &c.[2] In most of the cases above referred to, several tendons had been divided at different dates, thus multiplying the stages at which I have been enabled to investigate the reparative process in the human subject; I have now, therefore, ventured to submit the general results of my observations on this very interesting and hitherto unexplored subject to the critical opinion of the profession, in the confident belief that the conclusions to which I have been led by the facts now recorded will be confirmed by similar investigations which others may hereafter have the opportunity of pursuing.

[1] 'Trans. Path. Soc. of London,' vol. viii, London, 1857.

[2] 'Trans. Med. and Chir. Soc.,' vol. xlii, London, 1859.

CHAPTER II.

CASES AND POST-MORTEM EXAMINATIONS.

Case 1.—*Four days after operation* (Plate I, figs. 1 and 2).—F. William Paul, æt. 4 weeks at the time of operation; admitted an out-door patient at the Royal Orthopædic Hospital, 15th of October, 1857, being then only a fortnight old, for congenital talipes varus.

Operation performed by Mr. Wm. Adams, 28th October, 1857. The tibialis anticus and the tendo Achillis were divided.

Child taken ill on the 31st of October, with cold and bronchitis, and died on the 1st of November, 1857.

Post-mortem examination, 5th November, 1857.—Condition of parts:

Tendo Achillis.—The divided extremities of the tendo-Achillis were three quarters of an inch apart, but a direct connexion between them still existed by means of the cellular sheath of the tendon, which appeared to have been but little injured by the operation, and passed between the divided extremities in a tubular form, as shown in Plate I, fig. 1, *b*, *b*, and also in the diagram sketch, fig. 2, representing the sheath laid open. The sheath was highly vascular between the divided extremities of the tendon, and a close network of congested vessels ramified through its structure, which was a little increased in thickness and

slightly succulent in appearance, from infiltration into its cellular meshes. The vascularity extended above and below only for a short distance beyond the divided extremities of the tendon, and the surrounding fat and cellular tissue presented a blood-stained, vascular, and infiltrated appearance.

Within the connecting tubular portion of the sheath between the divided extremities of the tendon, was only a very small quantity of black coagulum, little more than a black streak of blood, not connected with either end of the tendon, as I have generally seen it in experiments, but lying in the centre, and corresponding to the puncture in the sheath. It was therefore evident that, in this instance, extravasated blood could take no part in the formation of the new connecting bond of union or the reproduction of tendon.

The divided extremities of the tendon were square, abrupt, and unaltered, either in appearance or texture. It might, perhaps, be said that the edges were slightly rounded, but the general appearance was that of a section just made.

The tibialis anticus tendon had been divided, and its extremities were separated to the distance of one inch. They were not so distinctly connected by the cellular sheath as the divided extremities of the tendo Achillis. It appeared as if the sheath had been completely divided, and in the drawing the want of any distinct connexion by the sheath, especially at the lower part, is shown. In the track of the tendon was a small quantity of black coagulum, represented in the drawing.

Both the cut extremities of the tendon had a square, abrupt, and unaltered appearance, as in the tendo Achillis.

The separation of the divided extremities of the anterior

tibial tendon was greater than might have been expected, but this tendon was tense and rigidly contracted, the anterior tibial muscle evidently playing a very important part in the production of the inversion.

The post-mortem examination was made at the child's residence, and under the strictest surveillance, so that the parts could not be removed for microscopical examination. A drawing only was permitted, and from the sketch taken by me at the time Mr. Ford's drawing has been made.

Case 2.—*Eleven days after operation* (Plate I, fig. 3).—Emily Ann Walton, æt. 8 weeks; admitted an out-patient at the Royal Orthopædic Hospital, 2d of December, 1852, for congenital talipes varus, of a severe form, affecting both feet. Operation performed by Mr. William Adams, on the 8th of December, 1852. The tibiales anticus and posticus, with the flexor longus digitorum, and the tendo Achillis of the right foot, divided. Child died on the 19th of December, 1852. No cause stated in case-book, but I believe it was diarrhœa. The case had proceeded in a most satisfactory manner, in respect of the operation and the treatment for the deformity.

Post-mortem examination.—Condition of parts:

Tibialis anticus.—The divided extremities of the tibialis anticus were seven eighths of an inch apart, but were connected by a solid bond of union, of a soft and somewhat gelatinous consistence, and blood-red colour. The surrounding tissue presented a blood-stained and vascular appearance.

Tendo Achillis.—The divided extremities of the tendo Achillis (*d, d*) were seven eighths of an inch apart, but were directly connected by a solid bond of union, equal in diameter to that of the tendon, but of soft consistence, and externally of blood-red colour, partly from blood-staining

and partly from vascular injection. The surrounding fat and cellular tissue also presented a blood-stained and vascular appearance, and were infiltrated with inflammatory effusion.

By a little dissection, I was enabled easily to define the connecting bond of union, the contour and definition of which evidently depended upon the cellular sheath of the tendon, the fibrous bands of which, now taking a longitudinal direction, were readily distinguishable.

The substance of this connecting bond presented, on section, a somewhat gelatinous appearance, of a reddish colour, partly from blood-staining, and partly from vascularity. There was nothing like separable blood-clot anywhere, and very little blood appeared to have been effused at the operation in this case. Both the cut extremities of the tendon presented a square and abrupt outline, the upper being only somewhat rounded at its margins. They retained their dead-white colour and natural texture, perhaps it might be said that they were slightly softer than natural, and thus contrasted strongly with the blood-stained gelatinous texture of the new connecting material; with this material, however they were pretty firmly connected, though to the naked eye there was no appearance of the dovetailing process of junction so obvious in the specimens at a later date.

The tibialis posticus tendon presented a very remarkable appearance, and it seemed very doubtful whether union would ever have taken place between its divided extremities; it appeared more probable that these would have remained adherent to the posterior portion of the sheath, where it lies behind, and in contact with the bone. The cut extremities of the posterior tibial tendon (*b*, *b*) were seven eighths of an inch apart, the lower extremity being drawn downwards very nearly to the lowest point of the

inner malleolus. Connected with each of these divided extremities was a portion of new material, like the connective tissue which forms the bond of union in other tendons, and essentially similar to that formed between the divided extremities of the Achilles tendon in the present instance, but at each extremity it was only a quarter of an inch in length. The portion of new material connected with the upper extremity was cylindrical in form, rather less in diameter than the tendon itself, and terminated below by an abrupt and square extremity.

The portion of new material connected with the lower extremity terminated above by a sharp point, but where connected with the end of the tendon was somewhat larger than it in diameter. These two portions of new tissue were of a ruddy tinge and firm consistence, but at the same time had a translucent appearance—say like darkly-coloured and very firm jelly. There was no direct connexion between them, and they were three eighths of an inch apart. A very small quantity of delicate areolar tissue existed in the sheath, but it did not appear as if this would form a connecting link between these portions of new tissue, and one could not therefore see how a direct and vascular connexion between the extremities of the tendon was likely to be established. Moreover, the pointed termination of the new tissue, connected with the lower extremity of the old tendon, corresponded in appearance with the same parts in Mr. Erichsen's case (No. 12), represented in Plate V, in which, two years after the operation, complete non-union was seen to exist in the posterior tibial tendon, the small portion of new tissue formed in connection with each of the divided and separated extremities of the tendon terminating in a conical point firmly adherent to the sheath behind the malleolus.

The flexor longus digitorum tendon had been divided, and its cut extremities (*c*, *c*) were half an inch apart, but were directly connected by a thin band of fibrous tissue, looking like stretched sheath or areolar tissue, surrounding the tendon. And by the infiltration of this tissue a new connecting bond would doubtless have been formed, and seemed to be in process of formation.

Microscopical examination.—In this case the tendons were removed for microscopical examination. The new connective tissue formed between the divided extremities of the tendo Achillis was seen to consist of nucleated blastematous material, in which, after the addition of acetic acid, numerous small, oval, and rounded nuclei were apparent; no linear arrangement of nuclei could be traced, except here and there where portions of the sheath, or included fibro-cellular tissue, existed in the portion examined. Before the addition of acetic acid, the general appearance, when examined both with the fourth and the eighth magnifying power, was that of a homogeneous or somewhat granular membranous material, dotted with minute molecules of oil. No fibrillation of this material was apparent; the margins of the portions examined had no disposition to split into fibres; but, after being either teased out with needles or compressed with the glass, still resembled torn, membranous material. This, I would observe, is generally characteristic of the new material, except at the later periods, when separable fibrous tissue is formed. A few granular cells of irregular size, but generally rounded in form, were also intermixed with the nucleated blastema, and were doubtless derived from a small quantity of inflammatory effusion.

The portions of new tissue formed in connexion with the divided and widely separated extremities of the tibialis

posticus tendon presented appearances essentially similar to those just described in the connective tissue of the tendo Achillis, but with less intermixture of inflammatory effusion, and a much smaller quantity of molecular oil.

I would observe generally, that in the new connective tissue formed to unite a divided tendo Achillis in the human subject, the presence of free oil in minute molecules, and in larger globules, as well as in some parts the presence of fatty tissue, is a constant appearance, the molecular oil being generally very abundant, and I think there can be no doubt that this is derived from the fat, which, together with the sheath, falls in between the extremities of the divided tendon, and amongst the fibrous elements of which the new material is effused. Small portions of included fatty tissue can frequently be seen with the naked eye.

This observation is very materially strengthened by what I have seen in my experiments, above adverted to, on the wild rabbit, in which animal there is no trace of subcutaneous fat in the leg, and very little in any other part of the body. In these experiments I found the new connective tissue always free from the molecular oil and oil-globules which constantly exist in the human subject, and which, in the various stages of the reparative process, may by some authorities be regarded as indicating essential changes in the structural elements, instead of being, as I regard them, merely accidental complications arising from the anatomical peculiarities of the structure in which the human tendo Achillis is imbedded.

Case 3.—*Sixteen, twenty-three, and thirty days after operation* (Plate II, figs. 1, 2, and 2, *a* ; and Plate VI, figs. 1 and 1, *a*, and figs. 2 and 2, *a*).—William Samuel Dodman,

æt. 3 weeks, admitted an out-patient at the Royal Orthopædic Hospital, on the 6th of January, 1859, for congenital talipes varus, of a severe form, affecting both feet. Operated upon by Mr. William Adams, on the following dates.

January 12th, 1859.—The tibialis anticus tendon of the right foot was divided. *Thirty days.*

January 19th, 1859.—The tibiales anticus and posticus tendons of the left foot were divided. *Twenty-three days.*

January 26th, 1959.—The tendo Achillis of the right foot was divided. *Sixteen days.*

This child died on the 11th of February, 1859, after an illness of three days, from acute pneumonia. Mr. Ford accompanied me to the post-mortem examination in this case, and the coloured drawings exhibited to the Medical and Chirurgical Society, and from which Plate II has been taken, were made by him at the time from my dissections. I also succeeded in obtaining possession of the left leg and the tendons which had been divided in the right leg, which were all exhibited to the society.

Tendo Achillis of the right foot. Sixteen days after operation.—The tendo Achillis had been divided rather less than half an inch above the os calcis, and the cut extremities (fig. 2, *c*, *c*) of the tendon were seen to be rather more than half an inch apart, but connected by a tough bond of new material, of a ruddy, blood-stained colour, equal in diameter and bulk to the tendon it served to connect, so that the cylindrical form of the tendon was still preserved. The external surface of the new connective tissue, or inserted portion of new tendon, was not, however, so smooth and well defined as that of the old tendon, and required careful dissection, in consequence of the surrounding fat and cellular tissue having been to some extent infiltrated with inflammatory effusion, and being of a blood-stained

colour. There had evidently been a little effusion of blood at the time of the operation, and, as I shall presently describe, a small clot was still seen imbedded in the new connecting tissue; the longitudinal bands of old fibro-cellular tissue, however, evidently belonging to the sheath of the tendon, and stretched between the divided extremities, formed a ready guide to the definition of the tendon.

When dissected, the transverse line indicating the junction of the old with the new tendon was very obvious from the contrast of colour, as well as by the irregularity of the surface of the new tissue. In all my examinations, up to three years after division, I have found it impossible to dissect the surface of the new tendon as cleanly as we can the old tendon, so as to have a smooth, glistening surface, though there is no difficulty in the general definition of the new portion of the tendon. A longitudinal section of the tendon was made, and the appearance is faithfully represented in fig. 2, *a*. The new connective tissue, rather more than half an inch in length, contrasted by its ruddy, or light blood-stained colour, with the opaque, white colour of the old tendon, the cut extremities of which retained much of their abrupt and square outline, the margins only being a little rounded; they appeared not to have undergone any material change, but were firmly connected with the new tissue by a very fine dovetailing arrangement of old and new tissue, scarcely traceable by the naked eye.

Imbedded in the new tissue, a little above the lower extremity of the old tendon, was a small clot of blood, not encysted, but easily separable from the proper reparative material, the organization of which it interfered with at this spot.

Microscopically examined with a fourth magnifying power, the connective tissue between the divided extre-

mities of the tendo Achillis appeared to consist of old fibro-cellular tissue, existing chiefly at the circumference, and such as probably formed the sheath or fibro-cellular investment of the old tendon, intermixed with a large quantity of granular, nebulous material, studded with molecules and larger globules of oil, which were abundant in in some parts, probably from included portions of fat.

At the junction of the new with the old tissue, a coarse separation of the structure of the old tendon into obtusely rounded bundles of fibres, between which the new material was inserted, was very evident, as represented in Plate VI, fig. 1, and the new tissue at this part, and also near the end of the old tendon, was much clearer than towards the central portion, and exhibited more of a nucleated blastematous appearance.

After the addition of acetic acid, the new tissue, at its junction with the old tendon (see Plate VI, fig. 1, *a*), was seen to be thickly studded with small, oval, and rounded nuclei, but without any disposition to a linear arrangement. The clearness of the new tissue in the immediate neighbourhood of the cut extremity of the old tendon was remarkable. The acetic acid also had the effect of defining more clearly the outline of the separated bundles of fibres of the old tendon, which now appeared at their cut extremities more angular and of an irregular, square outline, and in the structure of the old tendon the linear arrangement of elongated nuclei in parallel series was also clearly seen; this arrangement was disturbed only close to the cut edge of the tendon, where small, oval nuclei were irregularly disposed.

The blood at the circumference of the clot represented in the drawing ran irregularly into the connective tissue, but was easily recognised, by its coarsely granular, separable,

and amorphous appearance, from the finely granular, membraniform appearance of the new tissue.

Tibiales anticus and posticus tendons of the left foot. Twenty-three days after division (Plate II, fig. 1).—The anterior tibial tendon had been divided where it crosses over the ankle-joint, and its cut extremities (fig. 1, *a*, *a*) were now seen to be three quarters of an inch apart, but connected by new material or new tendinous structure, forming a cylindrical bond of union rather less in diameter and bulk than the extremities of the tendon it served to connect. One peculiarity existed, viz., that the new connective tissue was split into two bands, and as this splitting was also continued a little way into the old tendon above and below, either this split condition existed as a natural condition in the tendon previous to the operation, or it might have been produced in some obscure way by the sheath, or loose textured areolar tissue which surrounds the tendon, being stretched in two bands between the divided extremities of the tendon after the operation. The new connective tissue was easily distinguishable, by its ruddy tinge and appearance of vascularity, from the old tendon, and the transverse line of junction was distinct both at the upper and lower extremities. It was of tough consistence, and, as a bond of union, was strong.

Microscopically examined, the new connective tissue appeared to be composed of homogeneous or granular material, not separable or splitting into fibres, but intermixed with bands of old, fibro-cellular tissue, between which the reparative material had been effused. Acetic acid brought numerous small nuclei into view, but they were rounded in form, irregularly disposed, and without any disposition to a linear arrangement. At the junction of the new with the old tendon, the process of dovetailing by

the splitting of the fibrous tissue of the old tendon and insertion of the new material was coarser than generally met with.

The posterior tibial tendon had been divided just above the inner malleolus, and its cut extremities (fig. 1, *b*, *b*) were half an inch apart, but, like the anterior tibial tendon, were connected by a tough bond of new material, of a ruddy tinge and somewhat translucent appearance, contrasting, therefore, very strongly with the opaque, white glistening of the old tendon.

The new connective tissue was flat rather than cylindrical in form, even above where the tendon is flattened, and was somewhat wider, so as to appear rather larger than the ends of the tendon it served to connect. The new tissue was also pretty firmly adherent to the bone through the greater part of its length, so as to suggest a doubt whether free motion of the tendon could ever have been recovered, though by the elongation of adhesions sufficient motion might perhaps be obtained. A longitudinal section of this tendon was made, and the upper and lower extremities of the old tendon were seen to retain their abrupt and square outline, but slightly rounded at the margin, without any bulbous enlargement or dovetailing visible to the naked eye, yet they were firmly connected with the new tissue. Some very small portions of yellow, fatty tissue were seen to be included in the substance of the new tissue.

Microscopically examined, the organization of the new material and its development into tendinous structure was much more perfect than in the anterior tibial tendon, and it approached so closely in its structural arrangement the characters of well-formed tendon as to justify its being described as newly formed tendinous structure. The new tissue (see Plate VI, fig. 2) had a distinctly

fibrillated character, but this appearance was very pale and delicate when compared with the fibrous arrangement of the old tendon. The margins of the compressed portion of new tendon under the microscope would not split, or fray out into separable fibres or bundles of fibres, but more resembled the jagged margins of a bit of torn membrane. The separable, fibrous character is evidently very slowly acquired by the new material.

The addition of acetic acid (see Plate VI, fig. 2, *a*) brought into view elongated nuclei united by filaments in a linear arrangement, and running in parallel lines, with almost as much regularity as in the old tendon, but the nuclei, if they may be so considered, in the new tendon were dotted and more elongated than in the old tendon, in which the nuclei were clear and well defined.

At the line of junction of the old with the new tendon, a fine dovetailing arrangement, which was very evident before the addition of acetic acid, could not be traced after the addition of the acid, which showed a clear space, dotted only with the smallest nuclei, generally spherical or irregularly oval, but not at all elongated like the nuclei on either side of the clear space belonging to the new and the old tendon; these small nuclei were scattered without any regularity, and were rather placed crosswise, or opposed to the linear series on either side, than inclined to run in the same direction. Numerous vessels existed in the new tendon, and the larger trunks were directed transversely or obliquely across it, as if formed from the circumference towards the centre, and then dividing, the smaller branches were either continued obliquely or ran in a longitudinal direction.

With regard to this foot it should be observed, that only the anterior and posterior tibial tendons had been divided,

in accordance with the general rule, which I adopt in all severe cases of varus, viz., that of dividing the treatment into two stages.

In the first stage, I divide the anterior and posterior tibial tendons with the flexor longus, if possible; and afterwards, by gradually everting the foot, reduce it to the condition of talipes equinus, as shown in Plate II, fig. 1.

Then, in the second stage, I divide the tendo Achillis, and by flexing the foot, depress the os calcis and bring the foot into its natural relations to the leg, as shown in Plate II, fig. 2.

This foot was ready for the division of the tendo Achillis at the time of the child's death.

Tibiales anticus and posticus tendons of right foot. Thirty days after operation. (See Plate II, fig. 2.)—The anterior tibial tendon had been divided as it crosses over at the ankle-joint, and its cut extremities were nearly three quarters of an inch apart, but connected by a cylindrical bond of new tendinous structure, very nearly equal in diameter and bulk to the extremities of the tendon it served to connect. Both externally and on section, the line of junction between the old and new tendon was very distinct, and the new tissue preserved a ruddy tinge. The new connective tissue so closely resembled, in its naked-eye and microscopic characters, the connective tissue or new tendon already described in the corresponding tendon of the opposite leg, that it is unnecessary to give any special or detailed description of it.

The posterior tibial tendon presented some peculiarities which require special consideration. Externally this tendon presented a very light ruddy tinge a little above the inner malleolus, but this colour had no abrupt termination, as observed in the posterior tibial tendon of the opposite leg,

nor were there any transverse markings, such as in the latter tendon indicated the junction of the old with the new tendinous tissue. The cylindrical form of the tendon was perfectly preserved throughout, and it was not in any part adherent to the surface of the bone; in length, this tendon, which has been preserved, and was exhibited to the Medical and Chirurgical Society, measured half an inch less than the tendon of the opposite leg—the difference evidently depending upon the new tissue inserted in the length of the latter tendon. On a longitudinal section, the colour of the tendon was seen to be uniform in all parts; the ruddy tinge did not extend into its substance; its structure was also uniform, and no indications of the divided extremities could be traced either by the naked eye or with a microscope.

Now, as this tendon was supposed to have been divided, and the case had proceeded as favorably as if it had been divided—the prominence of the inner malleolus, due to the replacement of the navicular bone, has been well exhibited by the artist, though his attention was not specially drawn to the subject—it would doubtless by some be considered as exhibiting a very perfect condition of repair, and might well be adduced as an example of a linear cicatrix, in illustration of the *linear-cicatrix theory;* but the view I am disposed to take is that this tendon was never divided.

The light ruddy tinge noticed externally appeared to have resulted from increased vascularity and blood-staining of the tissues surrounding the tendon, and was the result of the operation or attempted division.

There can be no doubt that cases of varus, even of some severity, have been well cured without division of the posterior tibial tendon, and occasionally without the division of any tendons at all where the treatment has been commenced early and well attended to, as in this case; and

there can be as little doubt that the subcutaneous division of the posterior tibial tendon is an operation liable to failure, even in well-practised hands, and therefore the two facts of the operation having been attempted, and the case progressing favorably, cannot be regarded as any evidence of the tendon having been divided, when set against the absence of those indications of the operation which I have found in all the other cases I have examined, even as late as three years after division of the tendon. I have not had the good fortune to meet with any of those examples of perfect repair described by my colleague, Mr. Tamplin, in which no trace of the division of the tendon could be detected, either by the naked eye or the microscope.

Perhaps the favorable progress of this case without the division of the posterior tibial tendon, coupled with the facts proved in this paper, that in some instances the posterior tibial tendon altogether fails to unite after division, and in other instances becomes firmly adherent to the surface of the tibia, may suggest the doubt as to the advisability of attempting the division of the posterior tibial tendon in all but the cases of extreme severity occasionally met with, or in such cases as it can be proved that this tendon is especially contracted—as we generally use the expression—meaning, of course, the contraction of the muscle.

Case 4.—*Eighteen days after operation.*—Agnes Glibbery, æt. 3 weeks, admitted an out-patient at the Royal Orthopædic Hospital, on the 26th of June, 1851, for congenital talipes varus of the right foot, of a very severe form. Operation performed by Mr. William Adams, on the 2d of July, 1851. The tibialis posticus and flexor longus tendons were divided. At the time it was supposed, from a jet of blood, that the posterior tibial artery had been wounded or divided, and

therefore the anterior tibial tendon was left undivided, and a compress and bandage firmly applied, the foot being restored to the deformed position. The mother neglected to bring the child to the hospital for five days, and then it was found that a small, circumscribed, cutaneous slough had formed under the compress. This healed in a few days, and there were no indications of the formation of any aneurism.

Extension was gradually made, and the case seemed to be going on very well, but on the 18th of July the child was seized with diarrhœa, then very prevalent, and died on the 20th of July, 1851. At the post-mortem it was impossible to obtain the leg, but the divided tendons, together with the posterior tibial artery, and neighbouring soft parts, were removed. This was the first specimen of the kind I had obtained, and as Mr. Paget had recently published the results of his experiments on the repair of tendons, I requested him to examine and report upon the appearances presented, and placed the specimen at his disposal. This is now in the museum of St. Bartholomew's Hospital, No. 5^{24}. I had the opportunity of examining the specimen microscopically with Mr. Paget, who kindly furnished me with the following report:

"The tendon of the tibialis posticus was divided transversely, and the ends of its two portions lay about one line apart. The upper portion was grayish looking, succulent, and at its end slightly swollen and rounded, or bulbous; the lower portion appeared unchanged in texture, and its free end was rectilinear. Between the two, and attached especially to the end of the upper portion, was a firm, tough, elastic, grayish substance, apparently a connecting bond of reparative material, about a line in length, and less than half a line in width or thickness; smaller, therefore,

than either portion of the tendon. This substance was united to the adjacent tissues, yet could be dissected from them. Portions of it, examined with a microscope, appeared to be composed of reparative material placed among the filaments of fibro-cellular tissue, such as might have collapsed into the space between the separated ends of the tendon. It contained abundant blood-vessels, but was essentially composed of compact, closely wrinkled tissue, like that of new tendons in the rabbit, dotted with minute molecular matter. The addition of acetic acid made it quite clear, and showed in it a few nuclei, besides those of the blood-vessels that traversed it.

"The tendon of the flexor longus digitorum was divided somewhat obliquely. Both its portions were very slender, and the upper one was so wanting in firmness that it was difficult to trace its end; neither did there appear any distinct, new-formed bond of union between them; they were held together by white tissue, apparently the fibro-cellular, which had invested the tendon, and to which the portions of the tibialus posticus and their uniting medium were adherent.

"Comparing the results of this examination with those obtained by experiments on rabbits, one may observe these chief points of difference:

"(1.) The much less separation of the portions of tendon in the child; it was here only one line, while in the rabbit, in a limb of nearly the same length, it was commonly nearly an inch.

"(2.) The much smaller quantity of reparative material formed in the child. The bond of connexion was not only short, but smaller than either portion of the tendon.

"In the rabbit it was always larger than either, and encased the ends of both.

"Such differences correspond exactly with those observed in the repairs of injured bones in man and in animals, the abundant callus in the one injury answering to the abundant material for new tendon in the other, while, in both sets of injuries alike, the reparative material is in the human subject formed very sparingly.

"On the other hand, this examination accords in many points with those of the divided tendons of rabbits, especially in these points:

"(1.) The existence of inflammatory exudation directly under the wound.

"(2.) Its absence between and close to the separated ends of the tendon.

"(3.) The absence of blood at the very seat of division of the tendons.

"(4.) The swelling and succulence of the upper portion of the tendon.

"(5.) The general aspect of the reparative material, and, in the whole, its microscopic characters.

"(6.) Its adapted form, and nearly accomplished isolation from the surrounding parts."

With regard to the first of these conclusions, I would observe that in this particular instance, the slight separation of the divided extremities of the posterior tibial tendon, which was only about one eighth of an inch, whilst in my other post-mortems I have generally found it rather less than half an inch, may be satisfactorily explained by the treatment adopted, *i. e.* the non-division of the other tendons and the absence of extension in consequence of the supposed wound of the artery. The

general inference and comparison may perhaps hold good, but as the conditions are never equal—children treated for deformity, and healthy rabbits allowed to run about—a satisfactory comparison, as to the separation of the divided extremities, can hardly be made. It is, however, probably correct that in the human subject the reparative material is formed somewhat more sparingly, and it is certainly more slowly, than in rabbits. The points of resemblance enumerated by Mr. Paget, from this specimen, have been borne out by all the examinations I have made, and may very well stand as general conclusions.

I would add that there were no appearances of the formation of aneurism traceable on dissection, nor could I trace any indications of a wound in the posterior tibial artery, so that it would appear doubtful whether this vessel had been wounded.

Case 5.—*Five weeks and six weeks after operation.*—Elizabeth Avery, æt. 6 weeks, admitted an out-patient at the Royal Orthopædic Hospital, on the 24th of March, 1853, for congenital talipes varus of the left foot, not of a very severe form, and talipes calcaneus of the right foot, described as severe. On the 30th of March, 1853, the tibiales anticus and posticus and the flexor longus of the left foot were divided by Mr. William Adams, and on the 9th of April the tendo Achillis of the left foot was divided.

On the 14th of May, 1853, this child died of acute pneumonia.

At the post-mortem examination it was only possible to obtain possession of the tendons which had been divided, but a drawing of the parts *in situ* was made and was exhibited to the Medical and Chirurgical Society.

Tibialis anticus.—The divided extremities of this tendon

were separated nearly to the distance of half an inch, but were connected by a tough bond of new material, equal in thickness to the extremities of the tendon it served to connect, and presented, on section, a slight translucent appearance, and a pale ruddy tinge, but the colour was very slight.

The tibialis posticus and flexor longus tendons had both been divided, but the new material connecting these tendons, and consequently the separation of their divided extremities, was rather less than a quarter of an inch. The reason of the separation being less in this than in some of the other cases, was probably that the muscles were less contracted. The new connecting material was of a firm, compact texture, and pale colour, grayish, with a light ruddy tinge from vascularity. Both these tendons were adherent to each other, and also to the adjacent bone-surface, but these adhesions were not strong.

Tendo Achillis.—The divided extremities of this tendon were separated to the distance of only a quarter of an inch, but were firmly connected by a tough bond of new material, of a translucent appearance, and light ruddy tinge, from vascularity, readily distinguishable from the opaque white extremites of the old tendon. The junction of the new connective tissue with the cut extremities of the old tendon was indicated by the dovetailing process, which was clearly traceable in the section, and is indicated in the drawing, but there was no marked bulbous enlargement of the tendon at this part.

Microscopically examined, the new material taken from the tendo Achillis exhibited a delicate, fibrillated appearance, not splitting into separable fibres unless the portions examined were taken from the surface where old tissue was included, nor did the margins of the portions examined fray out in a fibrillated manner, like the old tendon, but, as in some of

the more recent specimens, resembled the torn edges of a portion of some membranous structure of homogeneous or finely granular appearance. The addition of acetic acid brought into view abundant nuclei, and an arrangement in parallel linear series was evident, so that a perfecting of the new connective tissue towards the characters of well-formed tendon was clearly traceable.

Case 6.—*Six weeks after operation.*—Henry Wiblin, æt. 9 weeks, admitted a patient at the Royal Orthopædic Hospital, under Mr. Tamplin, on the 23d of November, 1854, for congenital talipes varus of both feet, and of a severe form. On the 27th of November, 1854, Mr. Tamplin divided the tibiales anticus and posticus tendons, together with that of the flexor longus and the tendo Achillis. This child died on the 8th of January, 1855, after a short illness, the nature of which I omitted to record, and my examination was confined to the leg, which I managed to obtain, and is now in Mr. Tamplin's possession, but with his permission was exhibited to the Medical and Chirurgical Society.

In this specimen, several muscular irregularities, with additional tendinous slips passing between and connecting the various tendons around the ankle-joint and in the foot, existed, and though unimportant as regards the production of the deformity, might perhaps have influenced the result of treatment, and may therefore be mentioned. An extra muscular slip of considerable size existed on the outer side of the flexor pollicis muscle; its origin was by two heads, one flat and expanded from the deep fascia of the leg, and the other attached to the fibula; its tendon passed downwards into the sole of the foot on the outer side of the tendon

of the flexor pollicis, and there united with the tendon of the flexor longus digitorum. At the junction of these tendons they also received a large slip of tendon from the flexor pollicis, and the latter received lower down a slip of tendon from the flexor longus digitorum; thus were all these tendons connected in the sole of the foot. Anteriorly, from the tendon of the tibialis anticus, a slip of tendon passed off a little above the ankle-joint, and after being connected with the anterior ligament, ran along the dorsal surface of the metatarsal bone of the great toe, parallel with, but to the outer side of, the tendon of the extensor pollicis tendon, which passed between the two divisions of the anterior tibial tendon in its normal direction.

The tibialis posticus and flexor longus tendons had been divided a little above the inner malleolus, and were connected by a tough band of new material, a quarter of an inch in length, equal in bulk to the tendons it served to connect, and of a grayish appearance, but with some vascularity. In this mass of new material both tendons were inseparably fused, and as the new material was also closely and firmly adherent to the surface of the bone, a general adhesion of all the parts at the seat of operation may be said to have existed. How far this would ultimately have interfered with the free play of the tendons and the muscular power of the foot, it is impossible to say. Much remains yet to be ascertained by post-mortem examinations in these cases long after such operations.

The tibialis anticus had been divided and its cut extremities were separated to about half an inch, but in consequence of the splitting of the tendon and its connexion with the anterior ligament of the joint, its divided extremities were less distinct than I have seen it in other cases; they were, however, firmly connected by what appeared

to be a flat band of old, fibrous tissue, thickened by infiltration of new reparative material; the cylindrical form, with clear, marginal outline, was not preserved, as we see it in the tendo Achillis, for instance.

The tendo Achillis had been divided at the same time as the anterior and posterior tibial tendons, as is Mr. Tamplin's custom in children, even in severe cases. Its separated extremities were connected by a firm bond of new material, equal in thickness and bulk to the tendon itself, and rather less than half an inch in length. The depression of the heel did not appear to be complete in this case. The outline of the tendon could be easily defined, and the appearance was that of a good, solid union. On section, the new material presented a grayish, translucent appearance, so that it was readily distinguishable from the old tendon. There had evidently been very little blood effused at the seat of the operation, and therefore its ruddy tinge was less, but its vascularity was evident. The dovetailing process of junction of the new with the old tendon was very obvious, especially at the lower extremity, where this appearance was coarse, and the old tendon presented a slightly bulbous enlargement.

Microscopical examination.—Portions of the new connecting material, taken from the posterior tibial and the flexor longus tendons at the seat of operation, exhibited a very delicate, fibrillated appearance, *i. e.* the granular basis-material was striated, though it would not split into separable fibres, and after the addition of acetic acid a parallel arrangement of elongated nuclei, in linear series, was distinct; as usual, the portion examined was studded with molecular oil, and vessels were clearly traceable. The fibrillation was more distinct in the new tissue connecting the divided extremities of the tendo Achillis, but except

in some bands of old fibro-cellular tissue (sheath ?) it would not split into separable fibres. After acetic acid, a parallel arrangement of elongated nuclei was very distinct, and at the junction of the old with the new tendinous material the latter was clearer than in its central portion, and studded with very small, oval, or rounded nuclei, irregularly scattered over the field.

Case 7.—*Three months after operation.* (Plate III, fig. 1, and Plate VII, figs. 1 and 1 *a*.)—Emma Roberts, æt. 8 years; admitted an out-patient at the Royal Orthopædic Hospital, on the 21st of February, 1856, for talipes equinus of the right foot, associated with partial paralysis of the muscles of the leg, which occurred suddenly in the day-time, when she was two years old, the child at the time being rather feverish, but not considered to be ill. On the 27th of February, 1856, the tendo Achillis was divided by Mr. William Adams, and the deformity cured in a few weeks. This child died on the 25th of May, 1856, of acute inflammation and sloughing of the throat, and on the 29th of May I made the post-mortem examination together with Mr. Coglan, and here I would mention that we took the opportunity of examining the whole of the spinal cord very carefully, and could not detect any abnormal condition in any part. All the muscles of the leg below knee were in a more or less advanced stage of fatty degeneration, but this was variable in different muscles and portions of muscles. The gastrocnemius and soleus were yellow and fatty, but the muscular tissue not entirely destroyed. The form of the foot was quite natural, and the depression of the os calcis not at all excessive.

Tendo Achillis.—When exposed by dissection, the cylindrical form of the tendon was perfect and well defined on

its superficial and lateral aspects, but the definition of its deep surface was obscured by adhesions. At the seat of division its surface was not so smooth and glistening as above and below this portion, and from this part you could not dissect a loose, separable, cellular sheath. A slight increase of vascularity also identified the seat of operation.

On section, the divided extremities of the tendon were seen to be three quarters of an inch apart, but firmly connected by a tough and close-textured, solid bond of new material, equal in bulk and thickness to the tendon it served to unite, and of a slightly striated or fibrous appearance, which was added to by a few injected vessels running longitudinally through its texture. The vascular injection was more marked than I have seen it in any other specimen, and the new material, which was essentially translucent (and a small portion, when deprived of blood, had a grayish, translucent appearance), had a more ruddy tinge in the body than may generally be met with at this period.

The junction of the new material, or, as I have described it, the new tendon, with the old tendon, by the process of dovetailing previously described, was very clear and distinct, being rendered more so than usual by the ruddy tinge of the former. The cut extremities of the old tendon were slightly puckered in at the exact line of junction, especially at the upper extremity, so that the new material, for about an eighth of an inch, ensheathed the extremity of the old tendon, but beyond this, especially at the lower extremity, a slight bulbous enlargement of the old tendon existed. The margin of the deep surface of the new tendon exhibited some want of clear definition, from adhesions and thickening of the adjacent cellular tissue, an appearance well exhibited in the drawing.

Microscopically examined, the structure of the new connecting material, or new tendon, was seen so closely to resemble the structure of the old tendon, that careful observation was necessary to distinguish them. The new material presented a distinctly fibrous appearance, resembling that of the old tendon, more easily splitting into separable fibres than in any specimen I have examined at an earlier date. This appearance is shown in Plate VII, fig. 1. The addition of acetic acid rendered the tissue translucent, and brought into view numerous elongated nuclei, arranged end to end in parallel linear series (see fig. 1, *a*, of the same plate), an appearance also exhibited in the old tendon after the addition of acetic acid.

The reparative process, by regeneration of tendinous structure between the divided extremities of the old tendon—the portion of new tendon being three quarters of an inch in length—was beautifully illustrated by this specimen, one half of which I have presented to the Royal College of Surgeons.

Case 8.—*Three or four months after operation.*—The patient in this case, a boy, æt. 16 years, was operated upon by Mr. Tuson, of the Middlesex Hospital, for talipes equinus. The tendo Achillis was divided and the deformity cured. The boy walked well, but three or four months after the operation died of scarlet fever. My late colleague, Mr. Lonsdale, removed the specimen from the body, and I was indebted to him for the opportunity of examining it, but it had been some time in spirit, so that the recent appearances cannot be described. The divided extremities of the old tendon were very distinctly traceable and were separated to the distance of one inch and a quarter, but were connected by a tough bond of obscurely

fibrous new material, equal in bulk and thickness to the extremities of the tendon it served to connect, so that the outline of the tendon was preserved. The process of dovetailing of the new with the old tendon was obvious at the line of junction. A little below the centre of the new material, and evidently corresponding to the seat of the operation, the remains of a rather large clot of blood was observed, now dried and contracted, and included in the mass of new tissue. The reparation was imperfect at this part, and the marginal outline of the tendon irregular; a slight bulging existed, with a little contraction above and below it. Altogether, there was more appearance of local disturbance at the seat of the operation, from extravasated blood and probably inflammatory effusion, than I have seen in any other case. The new material presented the appearance of a more irregular interlacement of fibres than usual, but still the new tissue was very strong, and from its quantity the union of the divided tendon would be considered sufficiently perfect.

The specimen from this case is now in the museum of St. Bartholomew's Hospital.

Case 9.—*Seven months after operation.* (Plate III, fig. 2.)—John Simmons, æt. 10 years, admitted as in-door patient, into the Royal Orthopædic Hospital, on the 16th of November, 1854, under the care of my late colleague, Mr. Lonsdale, for congenital talipes varus. The boy was operated upon within a few days of his admission, and the case progressed favorably, but he was attacked with scarlet fever, then prevalent in the hospital, and on the 17th of June, 1855, was removed to the Middlesex Hospital, where he died two days afterwards. I made the post-

mortem examination with Mr. Lonsdale, and removed the parts.

Tendo Achillis.—The divided extremities of the tendo Achillis were one inch apart, or rather more, but were connected by a tough and very strong bond of new material, or new tendinous structure, equal in bulk and thickness to the extremities of the tendon it served to connect. The new material had a grayish, translucent appearance, with very little evidence of vascularity to the naked eye, but with slight traces of a fibrous arrangement of its structure; some fibrous bands, approaching somewhat to the opaque, pearly lustre of old tendon, passing obliquely through its substance. This appearance I have seen more marked in cases of a later date. The deep surface of this portion of new tendon was somewhat ill-defined, from its connexion with thickened bands of fibro-cellular tissue intersecting the adjacent fat.

Microscopically examined, the new material presented a distinctly fibrous character, and although not splitting easily into separable fibres, still the edges of any portion examined exhibited a tendency to such splitting, and in some parts would fray out into delicate fibres. The addition of acetic acid rendered the structure transparent, and the arrangement of elongated nuclei in parallel, linear series was distinct.

Case 10.—*In this case the tendo Achillis had been divided three times, at periods of about four months, seven months, and one year previous to death.* (Plate III, fig. 3.) —Harriet Newman, æt. 3 years, admitted as in-door patient into the Royal Orthopædic Hospital, on the 26th of June, 1854, under the care of my late colleague, Mr. Lonsdale, for congenital talipes varus. She was operated upon soon

after admission, but the case being one of unusual severity, did not progress in the most satisfactory way, and at intervals of a few months the tendo Achillis was twice redivided, without the deformity being completely cured at the time of death. She was attacked with scarlet fever at the same time as the previous patient, and on the 17th of June, 1855, was removed to the Middlesex Hospital, where she died two days afterwards. As in the former case, the post-mortem examination was made by Mr. Lonsdale and myself, and the parts removed.

Tendo Achillis.—This tendon presented features of unusual interest, because it exhibited the appearances left after it had been divided three times by subcutaneous incisions, at periods of about one year, seven months, and four months. The distance between the divided extremities of the old tendon at their point of widest separation was exactly one inch and a half, but within this space were two detached portions of old tendon, which, together, measured about half an inch in length, and these were firmly and intimately blended with the proper reparative material, or new tendinous structure, formed after the three divisions of the tendon at the periods above named, to connect the divided extremities of the old tendon. These detached portions of old tendon retained their opaque, pearly lustre, and were thus readily distinguishable from the intermediate portions of new connective tissue, which presented a grayish, translucent appearance, as seen in all the other specimens, some months after the operation; and the junction of the old with the new tendon by the process of dovetailing was obvious, both in the detached portions and at the extremities of the old tendon. The new tissue had but very slight traces of vascularity to the naked eye, and only slight indications of a fibrous arrangement of its structure.

The upper and the lower portions of new tissue did not materially differ in appearance, and it was difficult to say which was the result of the first and which the second operation; but the central portion of new material had a slight, ruddy tinge, and imbedded in its substance was the remains of a small clot of blood, no doubt effused at the time of the operation, which, in all probability, was that last performed, viz., about four months previous to death. The blood-clot was defined, but still it was less distinctly separable or capable of enucleation than I have generally seen such clots, especially when of large size and in the adult tendo Achillis. By some these appearances might be supposed to indicate that the clot had undergone partial organization, but of this there did not appear to be sufficient evidence.

Microscopically examined, the central portion of new connective tissue presented a less distinctly fibrillated appearance than either the upper or the lower portions of the new material, and though not splitting into separable fibres, it still presented a striated appearance, most obvious, as usual, in the thicker portions, under the field of the microscope. Fibroid material was intermixed with the amorphous-looking remains of the blood-clot, and at this part molecular oil was more abundant. The upper and lower portions of new tendon had a distinctly fibrillated appearance, and after the addition of acetic acid exhibited the parallel, linear arrangement of elongated nuclei previously described.

Case 11.—*One year and a half after operation.* (Plate IV, and Plate VII, figs. 2 and 2, *a.*)—For the opportunity of examining this specimen in its recent condition, and for the possession of half the tendon, I am indebted to Mr.

Curling, who amputated the leg in consequence of a recurrent fibroid tumour connected with the inter-osseous membrane, and involving the gastrocnemius and other muscles of the leg. A girl, æt. 9 years, was admitted into the London Hospital, on the 13th of March, 1855, under the care of Mr. Curling, with talipes equinus, coexisting with a hard and apparently circumscribed tumour in the belly of the gastrocnemius muscle. The deformity was stated to have commenced between four and five years previous to her admission, and to have progressively increased; the tumour was first noticed ten months before her admission. Mr. Curling attempted to remove the tumour, but "was disappointed in finding that the growth extended irregularly into the substance of the muscle; and as the whole disease could not be excised without removing the entire belly of the gastrocnemius, the dense, central portion and the diseased muscular substance immediately around were alone taken away."

Mr. Curling observes: "After the healing of the wound, which was somewhat protracted, I divided the tendo Achillis, in order to correct the extreme talipes equinus consequent on the growth. The girl left the hospital, able to walk, about three months after the operation. The girl was readmitted into the hospital on September 16th, 1856, on account of a return of the tumour in the calf of the leg and of the talipes equinus. The mother first noticed the recurrence three months after she left the hospital."[1] Mr. Curling attempted a complete excision of the tumour, but finding its connexions deep and extensive, at once performed amputation above the knee. Upon dissection, the

[1] 'Trans. Pathol. Soc. London,' vol. vi, p. 345, and also vol. viii, p. 345.

tumour was found to be connected with the inter-osseous membrane and the periosteum of both tibia and fibula. In its general and microscopic characters it corresponded with the class of tumours described as *recurrent fibroid*, but with some peculiarities, which are minutely described by Mr. Nathaniel Ward in the sixth volume of the 'Path. Soc. Trans.'

Tendo Achillis.—After exposing this tendon by dissection, it might be said, from a rough, external examination, that no traces existed of the tendon having been divided; its external form and size were quite natural, without any irregularity of surface, which was readily defined by dissection, nor was there any increased vascularity; but a closer examination showed that through two inches and a quarter of the length of the tendon its surface did not present such a smooth, glistening appearance as in the normal condition, and that in this portion we could not dissect from its surface the layer of loose-textured, areolar tissue which naturally surrounds the tendo Achillis, and is described as its cellular sheath. With the exception, then, of partial adhesion of the sheath, and a loss, to some extent, of the smooth, glistening appearance of its surface, the tendo Achillis presented its natural external appearance. After making a longitudinal section of this tendon, it was at once apparent that it had been divided, and that the divided extremities of the old tendon were separated to the distance of two inches and a quarter, but were firmly connected by a tough bond of new connective tissue, or new tendon, equal in bulk and thickness to the extremities of the tendon it served to reunite; it might, indeed, be said to be somewhat thicker than the old tendon, and appears so in the drawing, but this seemed to depend upon a want of exact definition along its deep surface, in consequence of

adhesions or, more correctly speaking, direct continuity with the thickened bands of fibro-cellular tissue belonging to the fat placed between the tendo Achillis and the deep fascia of the leg. This peculiarity of the deep surface of the new tendinous structure I have found in all the cases I have examined up to three years after the operation. The new connective tissue in this case presented a grayish, translucent appearance, contrasting very obviously with the opaque, white, pearly lustre of the old tendon above and below it, and exhibited only slight traces of vascularity. Its texture was homogeneous rather than fibrous in appearance ; it had no longitudinally fibrous arrangement, but some opaque, white, glistening fibrous bands appeared to traverse its structure obliquely, and, as seen in the drawing, presented on the cut surface a somewhat feathered appearance.

The line of demarcation between the new connective tissue and the divided extremities of the old tendon, or, as I should prefer to describe it, the line of junction of the old with the new tendon, was very distinct. The mode of union was obviously by a process of fine dovetailing ; the new material, easily recognised by its translucency, being inserted between the split fibres of the old tendon, which still preserved their opaque, pearly lustre. This dovetailing mode of junction was equally distinct at the upper and lower extremity of the divided tendon, and there was no appearance of any bulbous enlargement of the old tendon at either of its extremities.

Microscopically examined, the new connective tissue (see Plate VII, fig. 2, and fig. 2, *a*), or new tendon, in this case resembled very closely the appearances presented by the old tendon, portions of which were taken from a little above and below the line of junction for comparison. So close, indeed, was the resemblance, that it would certainly

have been difficult for any one unaccustomed to examine these structures to point out any characters by which they might be readily distinguished. There could be no doubt that the new connective tissue, so readily distinguishable by the naked-eye appearance of the recent section, viz., the grayish translucency of its texture, was, essentially and by its microscopic characters, entitled to be considered as an example of complete and perfect regeneration of tendinous structure; and when it is remembered that this newly developed or regenerated portion of new tendon measured two inches and a quarter in length, we may well admire the perfection of the reparative process.

The new connective tissue, or new tendon, presented very distinctly the appearance of separable fibrous structure, differing only from the old tendon in being more delicate and less readily separable, *i. e.* the mass did not split so readily into fibrous bands, the margins only fraying out, but still it had a distinctly fibrillated appearance. The addition of acetic acid did not render the new tissue so clear and translucent as in the cases at an earlier date (compare this, for instance, with fig. 1, *a*, in the same plate) at three months after the operation, nor was the arrangement of elongated nuclei in parallel series so distinct. The fibrous character of the new tissue remained faintly traceable long after the addition of acetic acid, and the appearance of elongated nuclei was obscure, so that the latter might well be supposed to be replaced by dark lines or spaces. The same might be said of the old tendon after the addition of acetic acid, faint tracings of fibres and indistinct, elongated nuclei taking the place of complete translucency and distinctly elongated nuclei, arranged in parallel series, as seen in the specimens of new tendon at an earlier date, and also in the tendinous structure in infants.

I would also observe that in this specimen, the dotted appearance of the new material from the presence of molecular oil was less than in many of the specimens at an earlier date, but still molecular oil was more abundant than in the old tendon.

Much of the interest which attaches to this case arises, not only from the circumstance that a portion of new tendon, two inches and a quarter in length, could be proved to exist between the divided extremities of the old tendon, one year and a half after its division, but that, coexisting with this additional length of new tendon, the deformity, viz., talipes equinus, had returned, and at the time of amputation the elevation of the os calcis existed in a well-marked, I might almost say extreme degree.

It is therefore proved that in this case the relapse of the deformity was not due to the contraction and absorption of the new connective tissue, and there can be no doubt that such relapse was due to changes taking place in the muscular tissue of the gastrocnemius and soleus muscles, viz., inflammatory retraction, resulting from the healing of the wound caused by the first operation, and also from the destruction of the muscular tissue, caused by the continued or, as it is said, recurrent growth of the tumour, which, commencing from the inter-osseous membrane and periosteum of the tibia and fibula, progressively involved the muscles of the leg. This case is at least evidence of the fact, that relapse of the deformity may take place from changes occurring in the muscular structures, whilst the new material formed to connect the divided extremities of the old tendon after a previous operation remains as a permanent tissue.

The same fact we shall see illustrated by the next case,

though the pathological changes in the muscular structure were of a different nature, and I believe it may be assumed, as a general truth, that when relapse of the deformity does occur, it arises from structural changes taking place in the muscular tissue—altered or degenerated as this may be in some cases—rather than from contraction and absorption of the connective tissue formed after any previous operation.

The specimen from this case is now in the museum of the London Hospital, but a section of the tendon is in my collection.

Case 12.—*Two years after the last operation, but a longer, though uncertain, period after the previous operations, in which the tendo Achillis and the tibial tendons had been divided several times.*—This case was one of non-congenital clubfoot, talipes equino-varus, of paralytic origin, in which relapse of the deformity had taken place after several operations.

History of case.—G. T—, æt. 37, a basket-maker, was admitted into University College Hospital on the 19th of September, 1856. His left leg was partially paralytic, and the foot contracted in the form of talipes equino-varus. This had existed from the age of two years, and was said to have been the result of a burn; but no cicatrices existed, and there can be no doubt that he had suffered from infantile paralysis, which had given rise to the contraction and deformity of the foot, one of the most constant and almost invariable results. He had also a contraction of the right knee-joint, which, in the notes taken by the dresser, it is said, had been inflamed after a fall, in November, 1852. He went to the Royal Free Hospital, and afterwards to Guy's. Suppuration did not take place, and he recovered, with a

deformed leg. The tibia was partially dislocated backwards, but the joint was not anchylosed. The leg could be extended to an angle of forty degrees, and flexed to ninety degrees.

In consequence of the paralytic and contracted condition of the left leg and foot, and the contraction of the right knee-joint, this man was in a very helpless condition as regards the power of locomotion, and could scarcely get about, even with the assistance of crutches. He positively refused to have anything done to the left foot, because, he said, it had been several times operated upon without benefit, but he consented to an operation being performed on the right knee-joint; and in the hope of giving the man one useful leg, Mr. H. Thompson excised the right knee-joint on the 1st of October, 1856. He progressed very favorably for the first month, but he then had a severe attack of erysipelas, which at that time was prevalent in the ward, and several large collections of pus were opened by Mr. Erichsen, who had the management of the case during Mr. Thompson's absence from ill health. He died on the 19th of December, 1856, and for the opportunity of dissecting the leg I am indebted to Mr. Erichsen.

History of the treatment of the deformity.—The man stated that he had been in several hospitals, and that the left foot had been repeatedly operated upon for the cure of the deformity, without success; but the dates of these operations were, unfortunately, not ascertained from him, and as he died without friends, no information could afterwards be obtained. A very important point, therefore, in the pathological interest of the specimen, in reference to the reparative process in tendon after subcutaneous division, is defective, and it is impossible to say what period after division, or stage of the reparative process, is represented in the conditions exhibited in all the tendons which have

been divided and redivided. I have ascertained, however, that some of the operations, including the division of the tendo Achillis and the posterior tibial and long flexor tendons, were performed about two years previous to his death, in Guy's Hospital, by Mr. Cock, who had the man a long time under observation, and took a good deal of interest in his case. Mr. Cock has been kind enough to refer to his case-book, and has sent me the following memorandum: "In November, 1854, I divided the tendo Achillis and also the tendons behind the malleolus internus. In January, 1856, I divided, pretty extensively, the plantar fascia, including portions of the muscles."

It is probable that some of the operations, especially one or two divisions of the tendo Achillis, had been performed long prior to this date, judging from the appearances presented by the new material on section, and especially from the indistinctness of the dovetailed appearance at the line of junction of the old with the new tendon presented after the more recent operations. I should suppose that both the operations on the posterior tibial and long flexor tendons had been performed within a short time of each other, judging from the close similarity presented in the appearances; one of these operations might have been performed before he entered Guy's Hospital, or they might both have been done in that institution, only one being recorded. It is certainly improbable that he submitted to further operative treatment after the great attention he received at Guy's Hospital, and when he entered University College Hospital he peremptorily refused to allow any further operative proceedings on this foot. In reference to the stage of the reparative process, therefore, we may pretty fairly conclude that the two divisions of the posterior tibial and long flexor tendons, and one division of the tendo

Achillis, had been performed about two years previous to his death, and that one or two divisions of the tendo Achillis had been performed prior to that date.

The external characters of the deformity were such as are ordinarily presented in a case of talipes equinus of paralytic origin, with a slight inclination inwards of the anterior portion of the foot. The inversion was more conspicuous in the specimen than is represented in the plate, which is taken from a point of view least calculated to exhibit this portion of the deformity, and from which it is difficult to represent it. The inversion of the anterior part of the foot had been well marked, sufficiently so, perhaps, to give the deformity the appearance of varus, but had been overcome by the two divisions of the posterior tibial and long flexor tendons. I shall therefore record the case as one of talipes equino-varus. The dorsal aspect of the foot was very prominent and irregular, the head of the astragalus especially projecting; and the plantar aspect deeply arched, in consequence of the anterior portion of the foot being bent backwards from the transverse tarsal joint, and of the plantar fascia, muscular, and deep ligamentous tissue in the sole of the foot being shortened and rigidly contracted. The foot, therefore, was very much bent upon itself from the transverse tarsal joint, and the effect of this condition —one of much more frequent occurrence than is generally described—is always to add to the apparent elevation of the tuberosity of the os calcis, and, in such cases, the os calcis is found, upon dissection, to deviate very slightly from its natural horizontal position. It was so in the present instance, as may be seen in the plate, by noticing the relation of the tuberosity of the os calcis to the malleoli. The toes were flexed, or bent in a claw-like form, as is constantly the case in long-standing paralytic deformities, in

which all the anterior muscles are paralysed and the feet have not been used in progression.

Appearances presented on dissection of the leg.—All the muscles of the leg, below the knee, were found to be in an extremely advanced stage of fatty degeneration, and of a yellow, fatty appearance to the naked eye, except the tibialis anticus and the inner head of the gastrocnemius, which were of a pale-red colour, and apparently but slightly degenerated. All the bellies of the muscles were much atrophied and diminished in size. I submitted every muscle to microscopic examination, and the appearances presented were as follows :

Tibialis anticus.—To the naked eye this was the only muscle of the leg which presented anything like a healthy appearance. The belly of the muscle was of a brownish-red colour (browner and lighter than a healthy muscle), and it looked like a muscle slightly degenerated. In some parts it was mottled with light yellow patches, as if fatty, and streaked with excess of fat between the bundles of fasciculi.

Microscopic examination.—Not quite healthy in any part, but a good deal of tolerably healthy muscular tissue. Fasciculi of normal size. Transverse striæ distinct in many parts, but not so clear as in healthy muscle. In other fasciculi very pale, and transverse striæ very indistinct. In some parts the fasciculi were large, pale, and filled with opalescent oil-globules, aggregated so as to give a granular appearance to the contents. This appearance was distinct from the small, refractive molecules of oil which existed in some fasciculi, and escaped free in the field. In these degenerated fasciculi no traces of transverse striæ existed.

Extensor pollicis.—To the naked eye, yellow and fatty, except a few narrow bands of light-brown muscular tissue.

Microscopic examination.—The light-brown muscular

bands exhibited large fasciculi, filled with yellowish, opalescent oil-globules, and presented a granular, fatty appearance. Transverse striæ only traceable in a few places, and then very pale and indistinct. Fatty and fibrous tissue increased. The portions of the muscle which to the naked eye had a yellow, fatty appearance showed no trace of fasciculi, but presented the ordinary appearance of fatty substitution, *i. e.*, vesicular fatty tissue, as described by Mr. Quekett, throughout.

Extensor longus digitorum.—The naked eye and microscopic appearances precisely the same throughout as in the extensor pollicis; but, if anything, rather more advanced, as the light-brown muscular bands presented no trace of transverse striæ.

Peronei.—To the naked eye, yellow and fatty.

Microscopic examination.—Fasciculi of average size, pale, and striæ very faint, containing opalescent oil-globules, and having a granular, fatty appearance. Molecular oil and fatty tissue abundant.

Gastrocnemius.—To the naked eye, yellow and fatty, except the inner head, which contained a good deal of brownish-coloured muscular fibre, intermixed with yellow patches, and separated by a great excess of fatty tissue, so that this portion of the muscle presented a mottled and streaked appearance.

Microscopic appearance.—Inner head muscular, fasciculi very pale, with indistinct transverse striæ. Fatty tissue abundant. Outer head, no trace of muscular fasciculi. Fatty tissue, *i. e.* fatty substitution throughout.

Soleus.—To the naked eye yellow and fatty, so much so that the fasciculated appearance of muscular tissue was lost.

Microscopic examination.—No trace of muscular fasci-

culi. Fatty tissue throughout, like the outer head of the gastrocnemius.

Flexor longus digitorum.—To the naked eye, yellow and fatty.

Microscopic examination.—Muscular fasciculi pale, with delicate transverse striæ. Fatty tissue abundant.

Tibialis posticus.—To the naked eye, yellow and fatty.

Microscopic examination.—Muscular fasciculi only indicated by faint outlines, and filled with yellowish, opalescent oil-globules, so that the fasciculi had a granular, fatty appearance. No transverse striæ. Fatty tissue abundant.

Flexor longus pollicis.—To the naked eye, yellow and fatty.

Microscopic examination.—No trace of muscular fasciculi. Fatty and fibrous tissue throughout.

Condition of the Tendons.

All the tendons were much below their natural size. The tendo Achillis presented a flattened, expanded appearance, and was connected on either side with the deep fascia of the leg by strong, membranous bands of adhesion, passing downwards from its lateral margins, so that it was impossible to define this tendon by dissection, as in the healthy condition. These membranous bands of adhesion were, no doubt, the result of the repeated operations to which this tendon had been subjected, and would materially have interfered with the success of any further division for the purpose of obtaining additional elongation.

The tendo Achillis and the posterior tibial tendon were longitudinally divided (see Plate 5, *a*, *a* and *e*, *e*), for the purpose of examining the relations of the new with the old tendon, and the appearances are well represented in the plate.

The tendo Achillis had evidently been divided three or four times, and at the seat of one of these divisions the new tendinous tissue appeared to have been cut through (letter *d* in Plate). New tendinous tissue was seen to be intermixed with the old tendon, a portion of which is represented at *c*, through a space of two inches between the letters *b* and *b* in Plate; but it was impossible to say exactly how much new tendon had been formed, though, probably, from an inch to an inch and a half.

The posterior tibial tendon had been once divided only half through, above the inner malleolus—a wedge-shaped portion of new tendon existing in this situation (letter *f* in Plate),—and once completely through, behind the malleolus (*g*). In the latter situation the divided extremities of the tendon (*h h* and *h h*) had never re-united. A small quantity of new tendon had formed in connexion with each of the divided extremities; but towards the centre, each portion of new tendon was firmly adherent to the anterior wall of the dense sheath (*i*) behind the malleolus.

The new tendinous tissue was readily distinguishable from the old tendon at the upper extremity, by the difference of colour—the new tissue (*j*) was of a grayish, translucent appearance—and by the abrupt line of demarcation; but no such distinctions existed at the lower extremity, and it seemed as if very little new tendon had been formed in connexion with the inferior extremity of the divided tendon.

This tendon, therefore, at once afforded an excellent example of the non-union of divided tendon, and also of partial division of the posterior tibial tendon, the subcutaneous section of which is more difficult than some surgeons might suppose. Non-union of a divided tendon is probably a very rare event, except when the operation is

performed in the dense portion of the sheath, as in the present instance, because in this situation there is an absence of the loose cellular sheath and areolar tissue which surrounds the tendo Achillis and other tendons in the situation usually selected for operation, and falls in between the divided extremities which they serve to connect, and at the same time form the matrix in which the reparative material is effused. The long-established practical rule at the Orthopædic Hospital is never to divide a tendon, whether in the hand or the foot, in the dense portion of its sheath, the fear being of adhesion and impaired mobility; but the greater danger is evidently non-union.

The tendon of the flexor longus digitorum muscle had been twice divided at points corresponding to the operations on the posterior tibial tendon. Seven eighths of an inch of new tendon (letter *k*) connected the divided extremities of the old tendon at the superior operation; and one inch and an eighth of new tendon (letter *l*) connected the divided extremities of the old tendon in a similar way, at the seat of the inferior operation. It is worthy of remark, that in both situations the whole of the new tendinous tissue had been formed below the line of incision made at the operation, as proved by the fact that the junction of the new tendon with the superior divided extremity of the old tendon at the highest operation in the flexor longus, exactly corresponded to the partial division of the posterior tibial tendon (letter *f*), and the new tendinous tissue is all below this point. When healthy muscles are operated upon, as in experiments on animals, retraction of the superior divided extremity of the tendon takes place, and the new tissue is formed partly above, and partly below the seat of division. In the present case no separation could have taken place at the seat of the partial division of the

posterior tibial tendon (*f*), therefore the exact line of the operation is still indicated; and with this line the superior divided extremity of the flexor longus tendon still corresponds. The advanced stage of degeneration of the muscular tissue above described, sufficiently explains the absence of muscular contraction and drawing upwards of the superior extremity of the divided tendon. The length of new tendon must therefore indicate the extent to which the foot had been restored towards its natural position, and it is certain that the inversion of the foot must have been very severe, the case probably having been one of complete varus, though at the period of death very little inversion existed, and it might almost be called a case of equinus.

The new tendinous tissue inserted into and elongating the tendon of the flexor longus digitorum muscle, presented to the naked eye a grayish, translucent appearance, and was thus readily distinguishable from the opaque, glistening, yellowish-white, old tendon; it formed a cylindrical cord connecting the divided extremities of the old tendon, and in diameter was nearly, but not quite, equal to the latter.

Microscopic examination of the new tendon.—Portions of the new tendon from all the situations in which it had been formed, were submitted to microscopical examination, and presented the same general characters as have been described by myself as existing in the newly formed tendon in rabbits, after subcutaneous divisions, and complete reparation. (See 'Transactions of the Pathological Society,' vol. vi, and the drawings in plate xviii of the same vol.; also 'Medical Times and Gazette' for January 12th, 1856.) Where the new tendon appeared to be of the oldest date, the fibrous tissue was seen still to be of a much more delicate character than in the old tendon, but otherwise closely resembling it.

Ultimate disposal of the newly formed tendinous tissue.—The appearances presented in this specimen are of great pathological interest in reference to the question of the ultimate disposal of the newly formed connective tissue, or, as it may properly be called, new tendon. The length of new tendinous tissue existing in this specimen in several situations—in none of which is it probable that the operation had been performed less than two years previous to death—was opposed to the theory still advocated by my colleague, Mr. Tamplin and some other orthopædic authorities, of this structure being of a temporary nature, serving only a temporary purpose, and then undergoing contraction, and at last complete absorption, so that the divided extremities of the old tendon re-unite, and a *linear cicatrix* alone remains. In the present specimen there can be no doubt that the new tendon was a permanent tissue, and it is important to observe that it existed in considerable quantity in the tendo Achillis, even though, from the repeated operation, it may be supposed that re-contraction and relapse of the deformity had certainly twice occurred. Any adapted shortening of the muscles of the calf, therefore, which may have taken place, must have been at the expense of the degenerated muscular tissue, and not of the newly formed tendinous tissue.

Possibly, however, the repeated operations were rendered necessary, not so much in consequence of any process of re-contraction, as by an insufficient length of new tendon being obtained after the previous operations; or by both of these conditions.

The posterior tibial nerve, which was not generally much atrophied or diminished in size through its course down the leg, was suddenly enlarged to about twice its normal size (letter *m*), at a point corresponding to the lower divi-

sion of the tibialis posticus and flexor longus digitorum tendons. The nature of this enlargement was specially investigated by Dr. G. Harley, of University College Hospital, whose description of the appearances presented is given below, and there can be little doubt that in this case the posterior tibial nerve had been divided.

An irregular distribution of the arteries of the leg, which had been carefully injected in the specimen, existed in this case. The posterior tibial artery was absent—a fortunate circumstance, as the nerve had been divided; but the peroneal artery, which occupied its ordinary position (letter *n*), was enlarged to nearly the size of the posterior tibial, and after giving off small branches, crossed the ankle-joint from the fibula towards the inner side of the os calcis—it might be said to wind round the superior and internal surfaces of the os calcis—and from this point, at which it represented the posterior tibial artery (letter *o*), though placed more to the outer side of the leg, and also much to the outer side of the posterior tibial nerve, its distribution in the sole of the foot, with the division into the internal and external plantar arteries, was normal.

Microscopical examination of the enlargement of the posterior tibial nerve in the above case.

The small tumour on the posterior tibial nerve commences at about one inch above the point where the nerve divides into the internal and external plantar branches. It extends upwards for three quarters of an inch, and, at its thickest point, measures seven eighths of an inch in circumference, which is three eighths of an inch more than that of the nerve itself. On making a longitudinal section of the tumour, it was easy to follow the course of the nerve-fibres,

and they were observed to be, individually, very little thickened, although collectively the increase in their diameter was very visible. To the naked eye, the common neurilemma, or vagina cellulosa surrounding the enlargement, appeared to be somewhat more dense than at any other point of the nerve. The same remark is applicable to the sheath or membrane encircling the funiculi.

On examining a portion of the nerve-substance microscopically, the tubular nerve-fibres were found to be well-formed, and showed very distinctly the normal sinuous outline and double contours. The nerve-substance was carefully examined throughout the whole length of the tumour, without anything remarkable being discovered, except that here and there a few of the nerve-fibres were somewhat granular in their interior, with the double contours consequently indistinct. This appearance might probably be attributable to the action of the spirit in which the preparation had been kept. The microscope showed that there was a considerable increase of cellular tissue distributed among the nerve-fibres, and this, with the slight thickening of the neurilemma, constituted, no doubt, the enlargement. As the tumour could not be said to possess any of the characters of an idiopathic neuroma, while on the other hand it very much resembled the enlargements found at the point of union of divided nerves, it may, I think, with safety be ranked among the latter class, especially as the presumptive evidence is in favour of its having been accidentally divided during some of the operations.

The microscopical examination of the posterior tibial nerve in this case was made by Dr. G. Harley, and appended as a report to the description of the specimen in the 'Transactions of the Pathological Society,' vol. viii, 1857.

The specimen from this case is now in the museum of University College Hospital.

Case 13.—*Three years after operation.* (Plate III, figs. 4 and 5; and Plate VII, figs. 3, 3, *a* and 4, 4, *a*.)—The two Achilles tendons from this case were removed by me from the body of a lady, Miss M. M. R—, who died at the age of forty-two years, from phthisis, on the 13th of September, 1854. Three years previous to her death I had divided these tendons for paralytic equino-varus of one foot and equino-valgus of the other foot. The case is related in the 'Medical Times and Gazette,' December 29th, 1855, in illustration of the benefit which may sometimes accrue from a combination of tenotomy and mechanical treatment in cases of the more complete paralytic deformities. The post-mortem examination was made by my friend Mr. Allen, of St. John's Wood, and myself. The deformity in both feet had been well cured, and remained so up to the time of her death, and she walked, with the assistance of steel supports to her legs, with considerable comfort, though from the paralysis, which came on at the age of five years, and laid the foundation of the mischief, she had never been able to walk for twenty-two years, and from the age of five to seventeen years had only walked a little with assistance.

Achilles tendons.—The divided extremities of one of these tendons were found to be an inch and a quarter, and the other one inch and an eighth apart, but firmly connected by a strong bond of union, or new tendon, equal in bulk and thickness to the extremities of the tendons it served to unite, and presenting a grayish, translucent appearance, by which it was readily distinguishable from the old tendon. The new material had, in

a more marked degree than I have seen in any other human specimen, a longitudinally striated appearance. The cut extremities of the old tendon were very distinct, from the contrast of colour above described; and the line of junction of the new with the old tendon indicated by a process of fine dovetailing, well exhibited in Plate III, figs. 4 and 5. The new material extended at its circumference slightly beyond, or, it may be said, ensheathed, the extremities of the old tendon.

Microscopically examined, the new connective tissue presented the appearance of well-formed tendon; and when portions of it were examined side by side with portions of the old tendon, the general resemblance was so close, that without the evidence presented by the recent section it might very well have been said that no material differences of structure existed in any part, the presence of any new material might have been doubted, and an inference favorable to *the linear cicatrix theory* drawn. The new tendon presented a distinctly fibrous appearance (see Plate VII, fig. 3), and the portions examined readily split into separable fibres at the extremities, but not so readily as in the old tendon; the fibrous tissue of the new tendon was also more delicate than in the old, and was dotted with minute molecules of oil. In the old tendon, however, molecular oil was very abundant, an appearance which I have not seen before in old tendon, and this, together with an increased separability of its fibrous structure (see Plate VII, fig. 4), might perhaps be regarded as changes of degeneration, depending upon the long-standing paralytic affection.

After the addition of acetic acid the new tendon presented a shaded, nebulous appearance (see Plate VII, fig. 3, *a*), with pale and indistinct traces of its fibrous structure, which the strong acid did not render completely trans-

parent or invisible, as in the specimens at an earlier date. Dark crooked lines in ill-defined parallel series appeared in this structure, as if the remains of the elongated nuclei, which I have described as existing in parallel linear series in the earlier specimens. In the old tendon (see Plate VII, fig. 4, *a*), the appearances after the acid were very similar, but the molecular oil was much more abundant.

This completes the series of thirteen cases, of the recent appearances of which, with one exception, I have been enabled to give a detailed account from my own dissection and microscopical examination. In all these cases the reparative process has been observed in different stages between four days and three years after the subcutaneous division of the tendons.

I also possess short notes of three other post-mortem examinations, which have been made by me at periods between one and seven months after the operation; and from one of these cases I have preserved a portion of the foot, but have no detailed account of the post-mortem appearances, nor were any drawings made at the time. I am not, therefore, enabled to state the exact length of new material formed in these cases, but can, with confidence, assert that the general appearances in these three cases corresponded with the others, above described, of about the same periods after operation.

CHAPTER III.

GENERAL SUMMARY OF THE REPARATIVE PROCESS.

The principal events in this process of development of new tendon after subcutaneous division, may, I believe, be described in a general summary, as follows. Let it be understood, however, that the description especially applies to the tendo Achillis. Essentially the reparative process is no doubt the same in all tendons; but as the anatomical conditions, under which tendons are placed in some situations vary; for instance, where tendons pass through dense tubular sheaths, as the tibialis posticus behind the inner malleolus, the flexor tendons along the fingers, &c., there is an absence of the investing cellular sheath, and of the fat and cellular tissue which surrounds the tendo Achillis and other tendons similarly placed; and as these conditions sometimes interfere with the perfection of the reparative process, to which I will afterwards refer, it will be better to limit the general description to the process as it appears to me to occur in the tendo Achillis, which I prefer for illustration, though it would equally apply to other tendons placed under similar anatomical conditions. The process, it appears to me, may be best described under the four following heads, under which the principal events may be most conveniently grouped. They cannot be considered as so many different stages, because two or three of the processes described are always proceeding simultaneously.

1st. *Immediate results of the operation.*—After the subcutaneous division of the tendo Achillis in the human subject, for the cure of deformities of the foot, separation of the divided extremities of the tendon takes place to a very variable extent. Under ordinary circumstances the separation of a divided tendo Achillis in an infant is about half an inch, and in the adult from one to two inches. This is produced in the following way: the upper portion of the divided tendon is drawn upwards by the contraction of the muscular fibres, and the lower portion is drawn downwards, in proportion as the foot is restored to its natural position. The separation must, therefore, depend upon the capability of the muscular fibres to contract, and also upon the flexibility of the ankle-joint; and as in deformities the muscular structures are found in all conditions, from that of health to complete degeneration, and as the ankle-joint is also found in every degree of rigidity, from the adapted shortening of the ligamentous and other structures, &c., the separation of the divided tendon will vary in a proportionate degree. The circumstances which limit the separation of the divided extremities of the tendon are —1st, degeneration of the muscular tissue, as in non-congenital cases of deformity of long standing and of paralytic origin, &c.; 2dly, rigidity of the ankle-joint, produced by a variety of causes, but in congenital cases principally by the adapted shortening of the ligamentous structures; and in the non-congenital cases by old inflammatory infiltration of the structures surrounding the joint, &c.; 3dly, old adhesions in the neighbourhood of the tendon, such as result from a previous operation, or other causes. Frequently two, and sometimes all three, of these conditions coexist, and in such cases scarcely any separation of the divided extremities of the tendon will take place at the time

of the operation, so that the surgeon may be led to doubt whether the tendon has been completely divided.

Influence of the sheath.—The separated extremities of the divided tendon still remain indirectly connected with each other through the medium of the cellular sheath of the tendon, by which I mean the loose-textured areolar tissue which closely invests and surrounds the tendo Achillis, and which is never divided, and often appears to be but very little injured, in a subcutaneous operation; it evidently yields before the knife as the latter passes through the tense tendon. Even if this cellular sheath should be completely divided as in an open wound, it would not retract with the tendon, in consequence of its connexion with the subcutaneous fat and cellular tissue in the human subject; and in rabbits, in which animals no subcutaneous fat exists in the neighbourhood of the tendo Achillis, it would not retract, in consequence of its connexion with the deep fascia and sheaths of the deeper tendons. The influence of the sheath, therefore, which I hold to be of great importance, is not destroyed, as has been supposed by Mr. Paget, by the open wound, though it is certainly impaired; and the reparative process in these cases is proportionably less perfect, but not to an extent permanently to interfere with the formation of a sufficient quantity of new tendon.[1] This cellular investment of the tendo Achillis, which is scarcely demonstrable as a sheath in an anatomical dissection, becomes very easily demonstrable as such after the subcutaneous division of the tendon, because the loose-textured areolar tissue, of which the sheath is composed, is then put on the stretch, and being very little

[1] See Experiments on the Reparative Process in the Tendons of Rabbits, after division by subcutaneous and open wound, in the 'Trans. Path. Soc.,' vol. vi. This paper is now appended to the present Essay.

injured in the operation, as I have explained, from its yielding before the knife, presents the form of a tubular sheath passing between, and connecting indirectly the separated extremities of the divided tendon. This is very readily demonstrated in the rabbit (see experiments previously referred to, and the accompanying plate, No. VIII, in which this appearance is represented). I have also seen the same condition in the human subject; and in Plate I, fig. 2, the appearance has been represented in a diagrammatic sketch.

A very small quantity of blood is generally effused at the time of the operation within the sheath, now of tubular form, and is seen adherent to the upper and lower extremities of the tendon, but principally to the upper extremity. In many of my experiments on rabbits, there was scarcely a trace of blood; and in two examinations in the human subject, a few days after the operation, I found only a very small coagulum, certainly not sufficient to take any important part by its organization (the possibility of such a process being admitted) in the formation of the large quantity of new tendon required to connect the separated extremities of the old tendon. If the effused blood should be sufficient to fill the sheath and infiltrate the surrounding tissues, the reparative process will be retarded and rendered proportionably less perfect. Such an event must be regarded as an unfavorable accident of the operation, instead of an essential part of the process, as it has generally been regarded, especially by the French and German authorities. In such cases, the greater part of the blood will become absorbed, and the remaining and firmer portion of the clot will be found at a late period enclosed in the midst of the new tendon; this I have witnessed in several instances both in the human being and in the rabbit.

At the time of the operation, then, the separation of the

divided extremities of the tendon, which remain connected by the sheath which now assumes a tubular form, and the effusion of a small quantity of blood, are the ordinary occurrences.

2d. *Commencement and nature of the reparative process.* —The true reparative process commences in the human subject by increased vascularity of all the structures at the seat of the operation, viz., the subcutaneous cellular tissue and fat, and the cellular sheath of the tendon, now of a tubular form, passing between and connecting the separated ends of the tendon. In the rabbit the increased vascularity is confined to the connecting tubular sheath. For this reason, then, I regard the increased vascularity of the sheath in the human subject as essentially the first step in the reparative process, the extension of the vascularity to the cellular tissue and fat being the necessary consequence of the existence of this tissue, but unimportant as regards the reparative process. Increased vascularity of the sheath is followed by infiltration of a blastematous material into its meshes, or spaces, between its fibrous elements, so that the sheath, now forming the matrix in which the reparative material is effused, presents a vascular and succulent appearance. In the human subject this effusion and succulency may sometimes extend to the surrounding cellular tissue and fat, especially in clumsily performed operations, which may be followed by inflammation; but essentially I do not believe it extends beyond the sheath, because in carefully performed operations, followed by appropriate treatment, viz., a compress and bandage applied immediately after the operation, the gap between the divided extremities of the tendon remains as a depression for several days; it does not become filled up, as it would do if the tissues were at once infiltrated; and an external examination by the finger readily

detects the square and abrupt extremities of the divided tendon freely moveable in the cellular tissue, which to the touch seems flaccid rather than distended by infiltration.

Development of the reparative material.—The blastematous material infiltrated into the meshes of the sheath increases in quantity, and, microscopically examined, exhibits the development of innumerable small oval nuclei. A few cells, of large size and irregular form, with granular contents, or perhaps with one or more nuclei, and studded with minute molecules of oil,—cells such as are met with in ordinary inflammatory effusions,—may also be found according to the extent of the inflammatory lymph which may be accidentally intermixed with the nucleated blastema, —so called by Mr. Paget, and described by him as the proper reparative material as distinguished from inflammatory lymph, in which development proceeds through nucleated cells, as in the ordinary exudation from a granulating surface. A blastematous material, then, in which the cell-forms do not pass in development beyond the stage of nuclei, appears to be the proper reparative material from which new tendon is developed, and any admixture of inflammatory lymph in which the ordinary inflammatory exudation-cells are developed, must be regarded as an accidental complication of the reparative process, instead of being an essential part of it, as is generally supposed.

The changes which subsequently occur in the nucleated blastema are—1st, the formation of capillary blood-vessels. In the specimen from a child, exhibiting the reparative process on the eighteenth day after division, above described, examined microscopically by Mr. Paget and myself, newly formed and forming capillary blood-vessels with their nucleated parietes were beautifully seen after the addition of acetic acid, and were very abundant. 2dly, the nuclei

assume an elongated, spindle-, or oat-shaped form, and are seen, after the addition of acetic acid, to be arranged in parallel linear series. Whether fibres are formed in this way, or in what manner the elongated nuclei are disposed of, may still be matter of opinion; but I am inclined to believe in the development of fibres from this process, after carefully examining numerous specimens, both in my experiments in rabbits, and in the specimens from the human being.

As a gradual change towards perfecting the new connective tissue in its structural characters and general resemblance to the old tendon, the divided extremities of which it serves to connect, a fibrillated appearance of the new tissue is traceable under the microscope, and, in the course of time, a more distinctly fibrous appearance, *i. e.* tissue capable of splitting into distinct fibres under the microscope, becomes developed. The fibrous tissue, however, always remains more delicate and less distinctly separable than in old tendon.

3d. *General appearance and structure of the newly formed connective tissue, or new tendon; and its ultimate disposition.*—By the development of the blastematous material above described, a solid bond of union is formed between the divided extremities of the tendon, of variable length, according to the distance between the divided extremities; and this appears to be generally from half an inch to an inch in children, and from one inch to an inch and a half or two inches in the adult; but it may occasionally exceed this, and yet retain its full strength and proportionate size to the extremities of the tendon it serves to connect. The greatest length I have witnessed in the human subject is two and a quarter inches, and this was in the tendo Achillis of a girl, aged 9 years, a year and a half after the operation.

—Mr. Curling's case, No. 11, above described, and the appearances are represented in Plate IV of the present series.

This connecting bond of union, or new tendon, as it may with propriety be called, is of a very tough consistence, and to the naked eye appears to be homogeneous rather than fibrous. A small portion of it cannot be split into fibres, but when teased out with needles on a piece of glass for microscopical examination, it spreads out like a portion of serous membrane, rather than splits into fibres, though its fibrous character is readily distinguishable under the microscope, as above described. There is, however, one very marked peculiarity of new tendon, even at a late period, viz., that, after the gradual subsidence of the vascular injection and consequent ruddy tinge of the new tendon, it presents to the naked eye a grayish, translucent appearance, a peculiarity which it has retained up to the latest period I have had the opportunity of examining it in the human subject, viz., three years after operation; and in the rabbit, one year after operation. This grayish, translucent appearance at once distinguishes the new from the old tendon in any specimen of which a section has been made in the recent state; but as the translucency is destroyed by spirit, which immediately renders the new tendinous tissue opaque, this indication is lost after the specimen has been put into spirit. Pure glycerine, or a solution of half glycerine and half water, preserves the appearance of translucency in the new tendon for a short time—a few weeks; but gradually this solution renders the old tendon translucent, and thus the contrast between the new and the old tendon is also lost. I am not aware of any fluid in which the appearance can be retained.

I would here observe that no section, in the recent state,

had been made of the human tendons presented to the Royal College of Surgeons by Mr. Tamplin, from the external appearances of which they have been adduced in support of the theory of *a linear cicatrix*, supposed to result from the contraction and complete absorption of the new connective tissue. These tendons (the tendo Achillis, and tibial tendons of a child aged nineteen months, in whom these tendons had been divided nearly eighteen months previously[1]) are said not to have presented externally any appearance of having been divided, and minute portions, taken by Mr. Quekett from different parts, exhibited in an equal degree the microscopic appearances of well-formed tendon. Hence it appears to have been assumed by Mr. Tamplin, that the new connective tissue had been completely absorbed, and that the divided extremities of the old tendon had again come into direct apposition, so that only *a linear cicatrix* remained. The fact that the new connective tissue, or new tendon, so closely resembles in structure the old tendon as to be scarcely distinguishable from it by microscopical examination, had not at that time been demonstrated, and it is to be regretted that the recent section, the most important test, was not made. Sections of these tendons were made some months since by Mr. Quekett and myself, but from the effect of spirit in destroying the translucency of the new tendon (if such existed), it was impossible to say whether any new tendinous tissue existed or not. There did appear to me to be some indications of a portion of new tendon in the tendo Achillis, but the traces were obscure, and as the tendon of the opposite leg was not preserved, it is impossible to say

[1] 'Pathological Catalogue of the Museum of the Royal College of Surgeons,' vol. ii, Nos. 358, 359, and 360.

whether any increased length of the tendon had been obtained.

So far as I have been enabled to form an opinion from the observations on the human subject, and experiments on animals now recorded, I believe that the newly formed connective tissue, or new tendon, remains during life as a permanent tissue, and as an integral portion of the tendon, the divided extremities of which it has been formed to reunite.

4th. *Influence of the divided extremities of the old tendon; junction of the new with the old tendon; re-formation of a separable sheath on the surface of the new tendon.*—The divided extremities of the old tendon take no active part whatever in the reparative process during its earlier stages, and have but a slender connexion with the new material when first formed. A little later, certain changes are observed to occur in the divided extremities of the old tendon, and these commence earlier and proceed more rapidly in the upper than in the lower extremity of the tendon. These changes are—1st. The cut extremities of the tendon, with their square surfaces and sharp edges, become a little rounded, and their structure slightly softened. 2dly. They become slightly enlarged, and exhibit a disposition to split, and thin streaks of new material, of a grayish, translucent appearance, are seen between the split fibres. This is the commencement of the junction between the old and the new tissues, and by the increase of new material between the split fibres of the old tendon, the extremity of the latter presents a slightly bulbous appearance. 3dly. At a later period this bulbous enlargement gradually diminishes, till the extremities of the old tendon again assume their natural appearance, and the new and old tendon become of uniform

diameter; but the appearance of a very fine dovetailing of the new material with the split fibres of the old tendon still remains, and in two cases above described was distinctly traceable in the recent section at intervals of a year and a half, and three years, after the division of the tendon.

This complete and firm junction of the new with the old tendon may be regarded as essentially the final stage of the reparative process; but proceeding simultaneously with it is a further perfecting of the structure of the new tendon, as to its density, the diminution of vascularity, general resemblance to the structure of healthy tendon, except in the translucency as above described, and in the external definition of form; but in all the specimens examined at late periods I have found *a want of definition along the deep surface of the new tendon*, arising from adhesions between this surface of the tendon and the deep fascia. In the human subject, the cellular tissue between the deep surface of the tendo Achillis and the deep fascia presents the appearance of having been infiltrated with lymph to a greater or less extent in different specimens, and its structure is proportionably increased in density and its fibrous septa thickened. It is no doubt this condition of deep-seated adhesions which limits the separation of the divided extremities of the tendon when subjected to a second operation, and hence arises the extreme importance of gaining sufficient length of new tendon after the first operation. When divided a second time, a tendon very rarely gives way with *a snap*, and the separation of its divided extremities is generally very slight. This I have found to be the case, even after an interval of ten years between the operations; but the adhesions would no doubt be much stronger when the first operation had been

clumsily performed, and followed by an unnecessary amount of inflammation.

Re-formation of a separable sheath on the surface of the new tendon.—Amongst the changes which the new tendon undergoes in its gradual improvement at a late period, I have observed the more or less perfect reproduction of a separable sheath on the surface of the tendon, such as I described as forming in the first stage the matrix in which the reparative material is effused.

This process of re-formation of the cellular sheath on the surface of the new tendon is accomplished more perfectly, and is more easily traceable, in rabbits than in the human subject. In my experiments on rabbits I found, between the second and third month after division, a separable layer of areolar tissue formed on the surface of the new tendon through its entire length; and above and below it was continuous with the cellular sheath surrounding the extremities of the old tendon, but it was neither so delicate nor so loose-textured as the cellular sheath of the old tendon; it adhered more closely to, and could not be so easily separated from, the surface of the new tendon. In dissecting from above downwards, or from below upwards, in either case from the old to the new tendon, and raising the investing cellular sheath, the line of junction of the new with the old tendon could be readily determined by this difference in the separability of the sheath, when no other indication was apparent.

In the human subject the same process takes place, but is not so easily demonstrated, owing to the existence of, and connexions of the sheath with, the cellular tissue and fat in which the tendon is imbedded, and which is entirely absent in the rabbit.

CHAPTER IV.

CIRCUMSTANCES WHICH MAY INTERFERE WITH THE PERFECTION OF THE REPARATIVE PROCESS, OR ENTIRELY PREVENT IT, SO THAT NON-UNION OF THE DIVIDED TENDON MAY RESULT.

Having now described the reparative process, as it appears to take place under the ordinary circumstances of health in a divided tendo Achillis, I would observe, that the process appears to be precisely similar in all other tendons which possess a cellular sheath and are similarly situated with respect to the surrounding soft tissues; or which possess a delicate membranous sheath, as the flexor tendons in front of the wrist-joint, and tendons in many other situations. These delicate thecal membranes appear to serve the purpose of connecting the divided extremities of the tendons after section, and, together with the loose-textured areolar tissue (imperfect cellular sheaths) in immediate contact with the surface of the tendons, no doubt materially assist in the reparative process.

But there are some circumstances under which the reparative process may be interfered with to a greater or less extent, so that union may take place through an imperfectly formed and attenuated uniting medium, or, it is said, that union of the divided extremities of the tendo Achillis may completely fail. I have never seen a case of

complete non-union in the tendo Achillis, and should feel disposed to doubt its occurrence, in consequence of the uninterrupted connexion of the cut extremities, which continues to exist after division through the medium of the sheath, which is never completely divided, and is often but little injured in a subcutaneous division; and if it should be completely divided, as in an open wound, the sheath does not retract with the tendon, in consequence of its connexion with the surrounding tissues, as above described. In the posterior tibial tendon, however, complete non-union does occur, from the absence of a connecting cellular sheath, and is probably of more frequent occurrence than may be supposed: but of this I shall presently speak.

The circumstances under which the reparative process in the tendo Achillis may be interfered with, and the union remain imperfect, are—

1st. Some constitutional defect in the reparative powers of the patient, or depressed vital power in the limb from paralysis.

2d. *Injudicious after-treatment from*—(*a*) not sustaining the temperature of the limb, especially in paralytic cases during very cold weather; (*b*) too early and too rapid mechanical extension, restoring the form of the foot before there is any evidence of the reparative material being thrown out, or of the commencement of the reparative process; (*c*) the mechanical treatment being altogether ignored, and the patient allowed to walk two or three days after the operation, the surgeon relying upon the unassisted powers of nature in walking to restore the form and functions of the foot;[1] (*d*) discontinuing the me-

[1] See 'Lancet' of 17th March, 1855, where this plan of treatment is advocated; and several cases given, in illustration of its supposed merits, by Professor Syme, of Edinburgh. The patients were en-

chanical treatment too early, and bringing the foot too quickly into use, by which the uniting medium may be elongated and weakened.

From any of these circumstances imperfect union of the divided tendo Achillis may take place, the uniting medium being imperfectly formed and attenuated, in some cases consisting of little more than the sheath of the tendon somewhat thickened. Of the very serious results arising from this failure of the reparative process, not only in interfering with the restoration of the functions of the muscles, but in the production of talipes calcaneus, essentially an incurable deformity, it is not my intention to speak. The practical deduction, however, seems to be, that the rate at which the separation of the divided extremities of the tendo Achillis is to be produced by mechanical extension in the cure of deformities must be regulated by the activity of the reparative process. Rapid extension would not, I believe, endanger the perfect union of the tendo Achillis in well-nourished infants and children, in cases in which there is no paralysis of the limb operated upon. But in non-congenital cases of deformity at all ages, when any paralysis exists, as it certainly does in a very large proportion of such cases, the extension must always be slow and proportionate to the rapidity of the reparative process, which is evidenced by the filling up of the gap between the divided and separated extremities of the old tendon, and can be felt by external examination and manipulation.

In a healthy infant operated on for varus, I always endeavour, after division of the tendo Achillis, to bring the foot to a right angle with the leg in a fortnight, but never

couraged to walk on the third day after the operation. See also observations on this subject by Mr. Adams, in 'Medical Times and Gazette,' April 28th, 1855.

under this time, and in very severe cases this cannot always be accomplished. In older children I vary this time from a fortnight to three weeks, according to the activity of the reparative effort, and in paralytic cases the time should be extended at least to a month or six weeks.

Complete non-union of divided tendons.

When tendons, situated *in dense tubular sheaths,* are divided, the reparative process appears liable to be more seriously interfered with, and if the divided extremities of the tendon are much separated, union sometimes completely fails, and the extremities of the tendon become adherent to the internal surface of the dense tubular sheath. I found this to have occurred in the posterior tibial tendon in one case (No. 12 of the present series), which I dissected two years after the tendon had been divided, and the appearances are represented in Plate V of the present series. (This plate has already been published in the 'Transactions of the Pathological Society,' vol. viii, plate x, London, 1857.)

In this case the posterior tibial tendon had been divided directly behind the inner malleolus, and in connexion with each of the divided extremities a small quantity of new tendinous tissue had been formed; but towards the centre, each portion of new tendon was firmly adherent to the anterior wall of the dense sheath behind the malleolus, so that the continuity of the tendon was completely interrupted.

In the post-mortem examination which I made in another case, eleven days after division of the posterior tibial tendon (Case 2 of the present series), there seemed to be very little prospect of union taking place; the small portions of new tendon connected with the divided extremities

of the old tendon were half an inch apart, without any connecting tissue between them. The appearances presented on the dissection of this case are represented in Plate I, fig. 3. I have also seen good reason to believe in the failure of union in this tendon in several instances during life, in which, after its division for congenital varus, the feet have become flat and everted, exhibiting a degree of weakness and peculiarity of form which I believe to result from this failure of the reparative process.

With respect to the cause and the condition which favour the non-union of the posterior tibial tendon, I would observe, if the posterior tibial tendon be examined carefully as it passes through the dense tubular sheath behind the inner malleolus, a small quantity of very loose-textured and delicate areolar tissue, in the meshes of which small particles of fat are entangled, will be seen on its surface, and the same appearance will be noticed in other tendons in their passage through dense tubular sheaths; sometimes there is also an imperfect layer of very delicate thecal membrane.

Now, it will be obvious, from this anatomical examination alone, that if the posterior tibial tendon, or any tendon similarly placed, be divided in a dense tubular sheath, and if the divided extremities of the tendon should separate, as I have shown they generally do, to the distance of half an inch, and sometimes to nearly an inch, there would be no tissue capable of holding in connexion these separated extremities. The small quantity of areolar tissue above described is not disposed as a regular cellular sheath, as there is no necessity for such a provision, but if the separation of the divided extremities of the tendon should not exceed a quarter of an inch, I think the areolar tissue described would be sufficient to connect them, and play the

part of the cellular sheath of the tendo Achillis in forming the matrix in which the new reparative material may be effused: if, moreover, in a sudden and wide separation of the divided extremities, this areolar tissue should be torn across, so that the ends of the tendon cease to have even this slender connexion, it would appear, from my examination in the case No. 2 of the present series, that the portions of this areolar tissue which remain attached to each end of the tendon may still serve as the matrix for the development of a small portion of new tendon connected with each extremity of the old tendon, but their junction may not take place.

In the second case above adverted to (see Plate I, fig. 3), the ends of the old tendon were separated to the extent of seven eighths of an inch, and connected with each extremity was a small portion of newly formed tendon, about a quarter of an inch in length. As there was no direct continuity between these two portions of new tendon, which were nearly half an inch apart, it seemed that there would have been no prospect of their ever coming into contact, and the only result of which I could see a probability was that of adhesion to the sheath, as in the first case adverted to, and represented in Plate V. Now, the question which arose in my mind with respect to the appearances presented in case No. 2 was, how were these portions of new tendon formed in connexion with the divided and completely separated extremities of the old tendon? To suppose that the new material had been effused from the divided extremities of the old tendon would be in opposition to all that I have seen in my experiments on rabbits and in the human subject, and opposed to the opinion I have formed as to the part played in the reparative process by the extremities of the old tendon. The only explanation which occurred to

me of this abortive attempt at the formation of a connecting bond of new tendon was, that the small quantity of areolar tissue connected with each extremity of the divided tendon formed the matrix (as by its structure and vascularity it is undoubtedly capable of doing) in which the new material had been effused and developed, and it appeared to me that traces of this areolar tissue, with its included particles of fat, might be detected as now forming a component part of the small portions of connective tissue described.

Even when the posterior tibial tendon is divided a little above its dense tubular sheath, as was the case in the specimen just described, there seems to be a danger of non-union, when the separation is wide, in consequence of the lower extremity being drawn into the tubular portion of the sheath. Hence, in a case of varus, in which the posterior tibial tendon has been divided, it is clearly desirable not to straighten the foot quickly, where this is practicable; and in my opinion, at least a fortnight or three weeks should be allowed to elapse, in order to ensure union before the foot is brought into a straight line with the tibia.

These circumstances, then, interfere with the perfection of the reparative process of divided tendons, as required for the cure of deformities, or may entirely prevent it, so that complete non-union of the divided tendon may result; and when we consider that the reparative effort required in tendons divided for the cure of deformities is not simply a joining of cut extremities, such as would be sufficient to unite a ruptured tendon (a process which might be compared with the union of bone), but consists in a perfect regeneration of tendinous tissue between the cut and purposely separated extremities of the old tendon, and that this newly developed portion of tendon is to form a permanent connecting bond of union, equal in bulk and strength

to the original tendon which it serves to connect, and from half an inch to two inches in length, so that the tendon operated upon is permanently lengthened to this extent, our surprise will be, not that there are so many conditions likely to interfere with the perfection of this reparative process, but that under any conditions the process of regeneration of tendon is as perfect as I have shown it to be, when the required conditions exist, and are preserved by appropriate treatment.

CHAPTER V.

CONCLUSIONS.

The *conclusions* which I would deduce from such observations as I have had the opportunity of making on the reparative process of tendons divided subcutaneously for the cure of deformities in the human subject, and above detailed, are as follows:

1st. That tendon is one of the few structures of the body, such as bone, cellular tissue, nerve-tissue, and blood-vessels, capable of reproduction or regeneration, and that the newly formed tissue acquires, within a few months of its formation, the structural characters of the old tendon so perfectly as to be, under the microscope, with difficulty distinguishable from it; but it does not acquire (at least it has not up to three years, the latest period to which these observations extend) through its substance the uniformly opaque, pearly lustre of old tendon; in the mass it retains a grayish, translucent appearance, streaked only with opaque fibres at a late period, so that the recent section affords an easy method of distinguishing the new from the old tendon.

2d. That when a tendon has been divided subcutaneously, for the cure of club-foot, and its cut extremities are separated and held apart during the active period of the reparative process, *i. e.* the first two or three weeks (as

by mechanical extension employed with variable rapidity in different cases, according to the activity of the reparative process), new tendon is formed, of variable length according to the extent of the separation, for the purpose of reuniting the divided extremities of the old tendon. The greatest length of perfectly formed new tendon thus obtained, and equal in bulk and thickness to the tendon it served to unite, which I have seen in the human being, is two inches and a quarter, and this was in the tendo Achillis of a girl, aged nine years, a year and a half after the tendon had been divided by Mr. Curling—Case 11 of the present series, the appearances of which are represented in Plate IV. It is probable that when the tendo Achillis has been divided in children for the cure of deformities, such as congenital varus, the length of new tendon is generally from half an inch to an inch, and in adults from one to two inches.

3d. That the process, by which new tendon is formed for the purpose of reuniting the separated extremities of a tendon divided by subcutaneous section, a detailed account of which has already been given, is essentially similar in animals and in man. That the perfection of the process is in direct proportion to the absence of extravasated blood and inflammatory exudation; and that the sheath of the tendon, when consisting of loose-textured areolar tissue, as in the tendo Achillis, and other tendons surrounded by soft tissues, is of importance—1st, in preserving a connexion between the divided extremities of the tendon; 2dly, in furnishing the matrix in which the nucleated blastematous, or proper reparative, material is effused; and 3dly, in giving definition and form to the newly developed tendinous tissue.

4th. That the ultimate perfection of the reparative pro-

cess by the regeneration of tendinous structure, and the elongation of a shortened muscle by the insertion of a portion of new tendon into its length, equal in strength to the old tendon, and closely resembling it in its microscopic characters, is marred only by the adhesion of the deep surface of the new tendon to a greater or less extent with the neighbouring fibro-cellular tissue. These adhesions may limit the free play of the tendon, but will not interfere with sufficient motion being obtained. In cases of relapsed deformity, however, in which the operation of tenotomy may be repeated, these adhesions will, in many cases, prevent sufficient separation of the divided extremities of the tendon being obtained. Therefore, if much separation be required, a second operation is generally unsatisfactory in its result, and beyond a second operation very little advantage can ever be obtained from operative treatment. Hence the necessity of the closest attention to the treatment after the first operation, and the explanation of the complete failure after repeated operations for the cure of deformities. The adhesions after several operations were so numerous and so strong along the tendo Achillis in Case 12 (see Plate V), that no further benefit could have been obtained by tenotomy in this case.

5th. That the perfection of the reparative process, especially in non-congenital cases of deformity, in which more or less paralysis frequently exists, and in which the reparative powers are proportionably feeble, may be interfered with by injudicious after-treatment, especially by the too early and too rapid mechanical extension, so that an elongated and attenuated uniting medium may be formed.

And also that when tendons situated in dense fibrous sheaths of a tubular form are divided, there is great danger of complete non-union, the divided extremities of the tendon

becoming adherent to the inner surface of the sheath, without any direct connexion with each other. This I have shown to occur in the posterior tibial tendon, when divided immediately behind the inner malleolus.

The practical rule, therefore, is never to divide a tendon as it passes through the denser portions of its sheath, and when the operation is performed near to such portions of the sheath the extension must be conducted very slowly.

6th. That there is no reason for believing that, in the treatment of deformities by tenotomy, direct approximation and reunion of the divided extremities of the tendon must be first obtained, and that the required elongation is afterwards to be procured by gradual mechanical extension of the new connecting medium, as we should stretch a piece of india rubber, the stretching process occupying at least a month or six weeks, according to the doctrine and practice of some orthopædic authorities of the present time; but, on the contrary, all my observations lead me to consider that the required length of new tendon should be obtained during the time occupied in its formation, *i. e.* from about two to three weeks under the ordinary conditions of health, but in paralytic cases, and also in patients of feeble health, this period may be doubled.

Therefore, the object of gradual mechanical extension during this time is *to regulate the length of new tendon*, 1st, *by forcibly overcoming ligamentous resistance in some cases*, especially in those of long standing and of congenital origin, in which it is difficult to separate sufficiently the divided extremities of the tendon; and 2dly, *by preventing a too rapid and excessive separation of the extremities of the tendon in other cases*, especially in those of non-congenital origin, in many of which the ligaments offer no resistance, and the reparative power is so feeble from partial or com-

plete paralysis, that rapid extension, separating too widely the divided extremities, would endanger their union; and also when tendons situated in or near dense tubular sheaths, as the posterior tibial, are divided, because it has been shown that in such situations, if the divided extremities be widely separated, complete non-union may result in consequence of the absence of a connecting cellular sheath. Hence the mechanical extension must always in its rapidity be proportionate to the activity of the reparative process, and in the tendo Achillis, and other superficial tendons, this can be judged of by external examination and manipulation.

7th. That the new tendon remains during life as a permanent tissue, and as an integral portion of the tendon, the divided extremities of which it has been formed to reunite.

I see no reason for believing that the newly formed tendinous structure has any disposition to undergo a process of gradual contraction, such as we see taking place in the cicatrices of the skin after burns, to which it has been compared; and that ultimately it becomes absorbed, the muscular structure at the same time becoming elongated by the force of the contraction of the cicatrix, so as to allow of the re-approximation of the ends of the divided tendon, and the formation of a "*linear cicatrix.*"

Difficult as it may be to conceive the occurrence of this process in infants, in whom the muscular structures are all essentially healthy, it appears to me to be impossible to conceive its occurrence in cases of paralytic deformity, in which the muscles of the calf are found to be in a most advanced stage of fatty degeneration, so that under the microscope scarcely a trace of muscular tissue can be found, this being replaced by fibrous and fatty tissue.

The explanation given of the mode in which deformities are supposed to be cured upon this *linear cicatrix* theory, viz., by "an altered sphere of muscular action," does not appear to be at all intelligible. Yet this is the theory at present in vogue, having been originally propounded, and being still maintained, by my colleague, Mr. Tamplin,[1] as a modification of the views of Stromeyer, and supported by my colleagues, Messrs. Brodhurst[2] and Coote.[3]

Upon this *linear cicatrix* theory, I am utterly unable to understand the use of tenotomy in the cure of deformities; whereas, in the facts demonstrated in the present essay, we see sufficient evidence that, in the cure of deformities, muscles are elongated by the increased length of their tendons, obtained by means of subcutaneous division, and the development of new tendon formed for the purpose of reuniting the divided extremities of the old tendon.

8th. That the effect of this permanent elongation of the tendons of retracted or shortened muscles, *i.e.*, muscles shortened by adapted growth or adapted atrophy, is not only to correct deformities mechanically, by increasing the length of the tendons—as a carpenter would lengthen a piece of wood by the insertion of another piece of wood—and thereby allowing certain bones to be brought into their normal anatomical relations; but that, having obtained this end, its higher physiological or dynamic object is to allow of motion being gained, or, as it may happen to be, regained, in joints which were previously rendered fixed and motionless by the retraction and structural shortening

[1] 'On Deformities,' p. 5. See also "Appendix."

[2] 'On Club-foot,' p. 103. See also "Appendix."

[3] 'Medical Times and Gazette,' January 9th, 1858. See also "Appendix."

of the muscles. The mechanical conditions necessary for motion are thus obtained, and if the muscles themselves—both those operated upon and their antagonists—are in a sufficiently healthy condition, voluntary motion is also obtained, and is followed by an increased development of the muscular structure, so that the bellies of the muscles operated upon progressively enlarge, and in a case of congenital talipes varus the gastrocnemius and soleus muscles, thus brought into use, attain in a few years a very fair proportionate size, instead of undergoing a process of progressive atrophy from disuse, as seen in cases of club-foot which have remained unoperated upon till the period of youth or adult life.

The effect of the operation in increasing the size of the calf is very conspicuous, when a case, which has been successfully operated upon at an early age, is compared with a case which has not been operated upon, or subjected to other treatment; and it is thus proved that, when the possibility of muscular improvement exists, the muscular strength of the limb is very materially increased, instead of being diminished, by the operation of tenotomy; in fact, that tenotomy in favorable cases must increase the power of the muscles operated upon, and also of the antagonist muscles. The extent to which muscular power is restored, with its attendant advantages, must of course depend upon, and be proportionate to, the healthy condition of the muscles, and *vice versâ;* so that, in cases of complete atrophy and degeneration of the muscular structure, as in old paralytic cases, the results of the permanent elongation of the tendons is purely mechanical.

Thus it appears to be proved that the idea of Delpech, of the mechanical action of tenotomy by elongating the tendons of the muscles operated upon; and also the phy-

siological action of tenotomy, as entertained by Stromeyer, are essentially true, either separately or in combination, according to the muscular condition of the limbs operated upon; but in ordinary cases of club-foot—say of congenital varus—in which the muscles are essentially healthy, though in a condition of structural shortening, the beneficial results of tenotomy are accomplished by a combination of the mechanical with the physiological effects of the operation, as above explained.

9th. That when recontraction of the foot takes place, and the deformity returns at a distant period after tenotomy, this does not depend upon absorption of the new material, or new tendinous tissue formed previously to unite the divided extremities of the old tendon; but upon structural alterations taking place in the muscular tissue, either of an active character as in spasmodic cases, or of a passive character as in paralytic cases, and those produced by position, &c., in which the muscles, by a process of *adapted atrophy*, simply adapt themselves to the altered mechanical relations of the parts with which they are connected.

In three cases of relapsed deformity of the foot examined by me, Nos. 10 (Plate III, fig. 3), 11 (Plate IV), and 12 (Plate V) of the present series, the new tendinous tissue formed after the previous operations remained, preserving its translucency and other characters, by which it could be easily distinguished from the old tendon. This fact must be regarded as additional, and I may say conclusive, evidence against the soundness of the *linear cicatrix* theory, and the supposed temporary nature of the new material above adverted to.

PART II.

A SERIES OF EXPERIMENTS

ILLUSTRATING

THE REPARATIVE PROCESS IN THE TENDONS OF RABBITS AFTER DIVISION BY SUBCUTANEOUS AND OPEN WOUNDS.

CHAPTER I.

INTRODUCTORY REMARKS.

Some observations explaining the objects sought to be accomplished by a series of experiments on rabbits, the details of which I am about to record, would appear to be rendered necessary, in consequence of my colleagues, Messrs. Tamplin[1]

[1] Mr. Tamplin, in a lecture just published, remarks: "I may here allude to some amusing experiments which have been made upon rabbits with the view of illustrating the mode of union of tendons after operation. They require notice, from the fact that diagrams of the results have been published in the 'Pathological and Medico-Chirurgical Transactions.' The rabbits unfortunately would not tolerate the confinement of the limb in splint and bandage after operation, but gnawed off these unwelcome appliances. Of necessity the union was most imperfect, and no more illustrates the actual

and Brodhurst,[1] in their published works, misinterpreting these objects, and assuming that I adduced the results obtained by these experiments on animals as identical in all respects with the results of subcutaneous operations performed on the human subject for the cure of deformities; whereas no such pretensions were claimed by me, though experience, derived from the numerous post-mortem examinations in the human subject now recorded, has confirmed the opinion I entertained, that in all the essential phenomena, both pathological and physiological, the processes are similar.

The length of new tendon formed in the human subject

union of tendons where proper precautions are used, than the false union of bone after fracture under similar circumstances would illustrate the normal union of fractured bone." (A Course of Lectures on the Nature and Treatment of Deformities. By R. W. Tamplin. 'Brit. Med. Journal,' June 16th, 1860.)

[1] Mr. Brodhurst, in his work on 'Club-foot,' observes: "Mr. Adams differs from former experimenters, and states that the space between the divided extremities of the tendon increases from one to two and a half inches. Now this is entirely at variance with what is known to occur both in man and animals, when the limb is kept at rest, and in a position to favour reunion. But in the experiments undertaken by Mr. Adams, and for which rabbits were chosen, after division of the tendon, the animal was allowed to move about without any protection to prevent motion of the limb. Union was effected, but the uniting medium was stretched and rendered weak."

Mr. Brodhurst concludes his notice of these experiments by observing: "For it appears to me that they were not made with his (Mr. Adams') usual acuteness of observation, and are calculated to mislead those who are less versed in the subject than himself." ('On the Nature and Treatment of Club-foot,' p. 103. London, 1856. By B. E. Brodhurst.)

From these observations, it is clear that both Mr. Tamplin and Mr. Brodhurst did not rightly understand the purely scientific objects of inquiry sought to be established by the experiments which I performed.

after operation would, however, depend upon the circumstances in each case as to the severity of the deformity and the rate of extension adopted. It would be absurd to suppose that I considered the length of new tendon formed between the divided extremities of the tendons in rabbits, separated to their utmost by muscular motion, in the active movements of the animal, during the reparative process, to correspond with and represent the length of new tendon formed in infants operated upon for club-foot, when the limb is kept at rest during the reparative process, and the foot brought into position by gradual mechanical extension. These experiments were not, at any time, supposed by me to explain more than the general pathology of the reparative process, which, indeed, might be regarded as a physiological rather than a pathological process.

In all these experiments I applied lint and a bandage to the limb immediately after the operation, but removed these generally on the following day, leaving the animals to move about free from all restraint. In a few rabbits, my late respected friend and colleague, Mr. Lonsdale, applied a straight metal splint, and bandaged the limb to it after operation. It was intended to keep the limb in this position, and the muscles in a state of rest; but the rabbits either gnawed off these bandages, or the legs became so swollen that it was necessary to remove the bandages. To me, this method of restraint appeared to be quite unimportant so far as the essential objects of the experiments were concerned.

The primary objects, then, which I had in view in performing this series of experiments on rabbits were to ascertain whether regeneration of tendinous structure actually occurred, and, if so, what was the precise nature of the process. More especially, I was desirous of ascertaining—

1st,—Whether extravasated blood, by its organization, took any share in the reparative process, or whether extravasated blood impeded this process.

2d,—Whether inflammation, with the effusion and organization of lymph, was essential or advantageous to the reparative process, or whether these events interfered with the true reparative effort.

3d,—What share the sheath of the tendon played in the process of union, as this point is one of great practical importance.

4th,—To what extent the reparative process was influenced by the mode of operating, *i. e.*, whether the tendon was divided by subcutaneous or open wound.

5th,—The influence of, or part played by, the divided extremities of the old tendon in the reparative process.

6th,—The microscopical appearances of the new tissue in its different stages of development, and especially with reference to its organization as a permanent tissue, more or less closely resembling the structure of healthy tendon, *i. e.*, the more or less perfect regeneration of tendinous structure, and the temporary or permanent character of this tissue.

Now it will at once be seen that these points could only be determined by reference to experiments on animals, since it was essentially necessary to obtain a large number of facts before any safe conclusions could be drawn—the animals being killed at certain fixed periods—so that the reparative process might be traced in all its stages; and it is needless to add that these data could not be supplied by post-mortem examinations on the human subject, except as opportunities occur during a period of many years.

CHAPTER II.

DETAILS OF EXPERIMENTS.

Tendons divided by subcutaneous section.

Second day.—Two legs: right operated upon by a friend; left, by myself.

Right leg.—Operation performed too high. Tendon divided one inch and a quarter from insertion, the division including some muscular fibres at this part. Puncture very small, closed by clot, slight injection around it. Ends of tendon one inch apart; interval filled with coagulated blood, a large quantity of which existed in broken black clots, not only in the sheath, but external to it under the skin. Ends of tendon as if just cut, square, and in the midst of clot. No lymph or reparative material could be recognised.

Left leg. (Plate VIII, fig. 1.)—Tendon divided half an inch above insertion, as in all my operations. On removing the skin, the parts generally appeared white, glistening, and clean, as if no operation had been performed. Minute cutaneous puncture closed by lymph, and surrounded only by very slight vascularity. Sheath feebly adherent to wound at the corresponding point; very slight vascular injection of sheath—not enough to give a general colour. The sheath had not been divided in the operation, and exhibited only a

small puncture; it still connected the separated ends of th tendon, and appeared as an empty, tubular, fibro-cellula membrane, of thin but strong and resisting texture. Th divided ends of the tendon were an inch apart, but were no apparent till the sheath had been longitudinally laid open Only a trace of blood, with a small quantity of coloure fibrine, or lymph, adhered to the upper end of the tendon, which was not swollen or succulent, but presented a perfectly natural appearance, as if just cut. Its edges were not, however, quite so sharp as those of the inferior extremity, which presented a very abrupt squareness. The anterior part of the sheath between the divided ends of the tendon was slightly thickened by infiltration, exhibited a little injection, and on its internal surface was a small quantity of lymph. This appeared to me to be the only indication of a commencement of the reparative process. The specimen contrasted strongly with the preceding, in the absence of blood and colour, and generally natural and healthy condition of the parts.

Fourth day. (Plate VIII, fig. 2.)—Cutaneous wound as seen from within, after reflecting the skin, larger than the preceding (measuring rather more than one eighth of an inch), its edges gaping, and separated by a small, dried, adherent clot; slight ecchymosis in the neighbourhood; a little injection, and a very small quantity of lymph.

Divided ends of the tendon one inch and a quarter apart, but pretty firmly connected by the sheath, which had not been divided, and was thickened in most parts, and slightly injected. A longitudinal section showed the tubular character of the sheath to be less distinct than in the preceding specimen, from the increased thickening of its substance and approximation of its walls. The thickening of the sheath was most conspicuous in the neighbour-

hood of the lower end of the tendon; it here presented a pale, greyish, succulent, infiltrated appearance, but was of firm consistence. The thinnest portion of the sheath was close to the upper extremity of the divided tendon. The sheath contained a streak of black coagulum along its middle third, and above and below this a layer of pinkish blood-coloured lymph, or fibrine, extended to the divided ends of the tendon, but always in contact with, and agglutinated to, the anterior wall of the sheath. This material had no connexion with the cut ends of the tendon. The upper extremity of the divided tendon was still abrupt and somewhat square, differing from a recent cut only in being a little rounded at its edges and rather soft. It was not succulent. The lower extremity of the divided tendon had also an abruptly square appearance; but its edges were a little rounded, and its structure rather soft, but not swollen or succulent. Thus it will be seen that no new reparative material connected the divided ends of the tendon, which were essentially connected by the sheath in a thickened condition, most conspicuous in the neighbourhood of the distal extremity of the divided tendon. The amount of extravasated blood was very small, and certainly not enough either to interfere with or assist in the reparative process.

Sixth day (two specimens). First specimen.—Cutaneous wound, seen from within, appeared to have been enlarged by a little ulceration. It was of an oval form, and measured rather more than a quarter of an inch in its long diameter. Lymph and pus surrounded it, and considerable vascularity existed in its neighbourhood. Beneath it was a softened clot, which, for nearly half an inch, filled the sheath.

The divided ends of the tendon were one inch and three eighths apart. Above and below the clot already

described, the sheath was almost of a blood-red colour from vascular injection. It was thickened, and infiltrated with new reparative material sufficiently to give it somewhat the appearance of a cord-like bond of union, rather less than the tendon in thickness. It was firm enough to admit of a longitudinal section, which was made from behind forwards. On section, the bond of union appeared as a tolerably firm material, of a bloody tinge, and slightly translucent. No clear distinction could be made between the thickened sheath and its contents. The upper extremity of the divided tendon had lost its abrupt squareness of outline, and was rounded and obtusely conical. It was not swollen or succulent, and its extremity could be separated without difficulty from the new connective material, in which it had the appearance of being ensheathed for a short distance. The reparative material was much less abundant in the short space between the clot and the distal extremity of the tendon, which retained much of its square outline and distinctness.

Second specimen. (Plate VIII, fig. 3.)—This specimen contrasted with the preceding in the absence of inflammation and extravasated blood, and in the more perfect and advanced condition of the reparative process. The minute cutaneous puncture was closed by a plug of firm lymph or fibrine, not easily removed. At this point the under surface of the skin was only slightly adherent to the surface of the sheath below. There was no vascularity in the neighbourhood of the wound, or appearance of inflammation in any part. The divided ends of the tendon were an inch and a quarter apart, but were not distinctly obvious till a longitudinal section had been made. They were connected by a well-defined, cord-like bond of union, of the same thickness at its upper and lower extremities as the

corresponding extremities of the cut tendon, or even slightly thicker, but diminishing towards the centre, where it was about two thirds the thickness of the tendon. The cylindrical definition of this connecting bond of new material evidently depended upon the sheath of the tendon, which did not appear to have been divided; externally, this presented a pinkish, mottled appearance, from slight vascularity. On section, the new connecting bond was seen to consist of a firm, tough material, homogeneous in appearance, and uniformly of a tinge between light brown and grey, with some degree of translucency. The slight vascularity appeared to be limited to its surface. This material contrasted strongly with the dense white, glistening extremities of the divided tendon, with which, both above and below, it appeared to be pretty firmly connected, rather by direct adhesion than by the process of dovetailing seen at the later periods. The cut extremities of the tendon preserved their squareness and abruptness of outline, but their edges were very slightly rounded and inverted; no disposition to swelling or succulency. They both had the appearance of being ensheathed to a slight extent; but this appeared to depend upon thickened sheath rather than new material, and was more conspicuous at the lower than the upper extremity. This explained why the line of separation between the old tendon and the new material was not visible externally, though so distinct on section. No distinction between sheath and new connective material could be traced through the longitudinal section. This specimen was a beautiful example of the perfection of the reparative process at this period.

Eighth day.—This specimen resembled in many respects the first specimen of the sixth day, the reparative process

having been to a certain extent interfered with by extravasated blood, and the external wound enlarged by ulceration, but the reparative process was more advanced; the blood had either interfered less with the new material, or had been partially absorbed; and the evidence of the inflammatory process was less. The cutaneous wound had been enlarged by ulceration, and measured rather more than a quarter of an inch in diameter. It was filled with dried, adherent coagulum, connected with the surface of the new reparative material below. The internal surface of the skin surrounding the wound presented a little vascularity, and was coated near the edges with a small quantity of plastic lymph.

The divided ends of the tendon were an inch and a quarter apart, but, as in the preceding specimen, were not distinguishable externally. They were connected by a firm, cord-like, or cylindrical bond of new material of about the same diameter as the tendon, but irregular through its middle third, which corresponded to the clot filling the enlarged cutaneous wound.

A section through the new connecting bond and old tendon showed precisely the same appearances as in the last specimen, with respect to the characters of the new material, divided extremities of the old tendon, &c. It was, however, rather thicker, and would have been a specimen of more perfect repair, had not the extravasated blood a little interfered with the organization of the connecting bond in its middle third. In this situation the clot was seen, on section, to extend more than half through the substance of the new reparative material, which was, therefore, in this situation, only continuous with the upper and lower portions in its deeper or anterior part.

Tenth day.—Cutaneous wound appeared on the inner

surface, but little larger than a pin hole, plugged with firm fibrine, which could be displaced, though not very readily. The wound had evidently not united, though extremely contracted, union having been prevented by the extremity of a fibrinous clot, afterwards traced into the substance of the new reparative material. No vascularity or appearance of inflammation. No appearance of extravasated blood beneath the skin. Divided ends of tendon an inch and an eighth apart. The external appearance of the parts in this specimen very closely resembled those of the preceding, and the process could scarcely be said to be more advanced. The divided ends of the tendon were connected by a cord-like bond of union, well defined, apparently moulded by the sheath, which was so closely identified with the new material as not to be separated from it, though easily traced above and below over the old tendon. The line between the old and new tendon was obscured externally by thickening of the sheath, extending a little beyond the cut extremities.

The new connecting bond exhibited but little colour, and in its central portion was not quite equal in thickness to the old tendon.

On section, very nearly the same appearances presented themselves as in the preceding specimen, with respect to the cut extremities of the old tendon and the characters of the new material; but in the substance of the connecting bond, in its middle third, was a small fibrinous clot, elongated and cylindrical in form, pale and tough, rather than friable as the other clots, but not identified with the new material, easily capable of enucleation, and not presenting any appearance of a disposition to become organized, and form part of the new connective tissue. The lower extremity of the old tendon was slightly enlarged

by the separation of its fasciculi, and insertion of new material between them.

Twelfth day. (Plate VIII, fig. 4.)—The reparative process in this specimen was less perfect than in the preceding, in consequence of extravasation of blood and inflammation.

Cutaneous wound enlarged to a quarter of an inch by ulceration, and plugged with fibrine a little softened; considerable vascularity in the neighbourhood of the wound; and the internal surface of the skin covered with soft lymph; general adhesion to the new connecting bond through its lower half and at the part corresponding to the external wound and the coagulum, in which situation very little new connecting or reparative tissue existed. Above this point, *i.e.*, near to the upper and lower extremities of the divided tendon, the new material was abundant, and quite equal in thickness to the old tendon, but was more vascular than in the other specimens.

The cut extremities of the old tendon were an inch and a quarter apart, and were seen, on section, to be more inverted and rounded than in the other specimens; from the new material being of a grayish, translucent appearance, the contrast with the dense white colour of the old tendon was great.

The lower extremity of the old tendon was enlarged to a greater extent than in the preceding specimen, by the same process of insertion of new material between its separated fasciculi, and was of a somewhat bulbous form; the extremities of these fasciculi slightly converged, the separation being greater a little beyond the cut surface.

Sixteenth day. (Plate VIII, fig. 5.)—This specimen was an example of very perfect repair, apparently without any interference either by extravasated blood or inflam-

mation; but the new connecting bond was slender in the middle, as if from elongation by excessive use; it was nearly half an inch longer than in any of the preceding specimens.

Cutaneous wound firmly sealed and scarcely traceable. No appearance of inflammation or extravasation of blood. The divided ends of the tendon were an inch and five eighths apart, but they were connected by a firm, cord-like bond of new material, equal in bulk to the thickness of the tendon for very nearly a quarter of an inch beyond each cut extremity; it then suddenly diminished, and through the central part was scarcely more than one third diameter of the tendon above and below. The general appearance, therefore, was that of the divided ends of the tendon, above and below terminating in conical extremities, slightly enlarged beyond the natural dimensions, and connected in the middle by a cylindrical bond of new material. The line between the old tendon and new material connected with it was not distinctly indicated externally. On section, the superior cut extremity of the old tendon was seen to be a little rounded, inverted, and somewhat conical in outline. The lower extremity was more distinctly enlarged and bulbous than in the preceding specimens, and seemed to consist of three principal divisions; the tendo Achillis appeared to be about equally divided into two portions longitudinally, and the small flat tendon which passes superficially over the tendo Achillis, and round the os calcis towards the foot, made the third. The superficial and deep portions converged towards each other at their cut extremities, whilst the central portion was slightly depressed. The new connecting material had a grayish tinge, and exhibited slight vascularity. The distinction between it and the old tendon was well marked and conspicuous.

It was tougher than in the preceding specimens, but not distinctly fibrous.

Eighteenth day.—This specimen very closely resembled the preceding in every respect; no appearance of inflammation having existed, or of extravasation of blood.

Cutaneous wound scarcely to be traced. The divided extremities of the tendon were very nearly an inch and three quarters apart. The lower end of the tendo Achillis was slightly enlarged, and inclined to a bulbous form at and a little below its cut extremity. To a less extent, this also existed at the upper extremity. The new connecting cord-like bond of union was attenuated through rather more than its central third.

On section, the appearances were very similar to those described in the preceding specimen, but the central portion was more vascular, and the bulbous appearance of the lower extremity of the divided tendon was seen to depend partly upon thickening of the surrounding portion of the sheath, and partly upon a splitting of the great tendinous divisions and smaller fasciculi between which the tough, grayish new reparative material extended, dovetailing, as it were, with the old tendinous fasciculi, which still converged at their cut extremities, towards which they passed in a curved direction, rather than in parallel and straight lines.

The new material did not present to the naked eye a fibrous appearance. Neither in this nor in any other specimen was it more abundant at the upper than the lower extremity. If anything, the excess generally appeared to be at the lower extremity.

Twenty-second day.—Cutaneous wound scarcely traceable, no trace of extravasated blood or inflammation having existed. The separation of the divided extremities of the

tendo Achillis varied from an inch and a quarter to an inch and a half, in consequence of the section having been made obliquely. The lower extremity of the tendon was less bulbous than the preceding.

The appearance on section was similar to the last in most respects, but the new material was uniformly paler, without any central vascularity, and it presented to the naked eye some indications of a longitudinally striated or fibrous appearance; it was not attenuated in its centre, but of uniform diameter throughout, and equal to that of the tendon.

Twenty-sixth day. (Plate VIII, fig. 6.)—In all essential respects this specimen much resembled the last; but the new connecting bond was somewhat thicker in the middle, and although longer than the preceding, was of uniform diameter, except near to the divided extremities, where it rather suddenly expanded above and below. In its central and cylindrical portion it was nearly equal in diameter to that of the healthy tendon. This was the most perfect specimen of the series. The divided extremities of the tendo Achillis were fully an inch and three quarters apart. The appearances on section were very similar to those of the last specimen. The new connecting material was pale throughout, and more distinctly fibrous. The cut extremities of the old tendon were less distinct, and blended more intimately with the new material. This was more obvious at the upper than the lower extremity, as was also the case in the two preceding specimens. The insertion of the new material between the fasciculi of the old tendon, which were slightly separated thereby, was more obvious at the lower than the upper extremity; still the dense, opaque, white colour of the old tendon contrasted, a little beyond the cut margin, with the grayish, semi-translucent

appearance of the new reparative material. The lower extremity of the old tendon was enlarged and slightly bulbous close to the junction with the new material.

Fifty-fourth day. (Plate VIII, fig. 7.)—This was a beautiful example of the most perfect repair. The cutaneous puncture was not traceable. There were no traces of inflammation or extravasated blood. The skin could be dissected from the new tendon almost, if not quite, as easily as in the healthy condition, the most delicate cellular connexion only existing.

The divided ends of the tendon were very nearly two inches apart, but this could not be ascertained till a longitudinal section was made, and then was difficult to determine exactly, from the intimate connexion of the old and new tendon at the upper extremity, by dovetailing. It might be stated at more than two inches, but very little less. There was no enlargement or bulbous appearance of the old tendon at its lower extremity, which appeared to be about its normal size, as also did the upper extremity.

The general appearance of the new connecting bond externally was precisely similar to the old uncut tendon in respect of form; it was cylindrical, and of uniform diameter throughout—equal in thickness to the normal tendon, and resembling it in every respect but colour. There was an absence of the opaque, white, glistening appearance of old tendon, and it presented a slightly translucent, grayish appearance. Held up to the light, it was seen to be very distinctly translucent; the line of demarcation between the old and new tendon at the lower extremity was very obvious and abrupt; this could not be traced at the upper extremity, where the shading from translucent to opaque tissue was very gradual. There appeared to be some attempt at the formation of a new sheath over this new

tendon, from the surface of which a layer of delicate areolar tissue could be raised, though not so readily or perfectly as from the old tendon. The appearance of the new connecting bond, on section, was that of a pale and tough, grayish, translucent tissue, having a very delicate but obviously fibrous appearance in a longitudinal direction. No vessels were apparent to the naked eye. Above and below, it was firmly and inseparably connected with the ends of the old tendon. This appeared to have been effected by the insertion and organization of the new material between the fasciculi of the old tendon, which perhaps wasted to a certain extent after some time, as at this period no enlargement existed, such as seen in the earlier stages.

The difference of colour very obviously indicated the old and new tendon, and the lower extremity of the old tendon still presented an abruptly square outline; but a minute inspection showed a mingling of new translucent tissue with the old tendinous fasciculi, giving a shaded appearance. There was no inversion of the cut extremities of the old tendinous fasciculi, as in the specimen examined on the twelfth and sixteenth days; they were longitudinally parallel; and this restoration to their normal direction appeared to depend upon the absence of the bulbous form in those specimens. At the upper extremity, the new and old tissues were so gradually blended as to render it impossible to say precisely where the one began, and the other ended. The junction might be said to be by a very short dovetailing process below, and a very long one above.

The small tendon which lies upon the tendo Achillis was quite separate from it at the lower extremity, and this separation extended into the new connecting structure

for fully one eighth of an inch, and was indicated for a quarter of an inch above this. At the upper extremity the small tendon could not be traced.

Sixty-second day.—In all the more essential points, this specimen very closely resembled the preceding. I could see nothing, either in the external appearance or on section, to indicate any more advanced or more perfect condition of the reparative process. It presented only one peculiarity, viz., that the total length of the tendon was very nearly, if not quite, half an inch longer than that of the opposite leg of the same rabbit last described; and this appeared to be due to elongation of the new material having taken place at a late period. The new connecting bond was very decidedly thinner than in the last specimen, its diameter being probably from one fourth to one third less. It had an elongated and attenuated appearance, and measurement taken from the longitudinal section showed the increased length of the tendon to be due to the increased length of the new connecting material, which was about two inches and a half in length.

The divided ends of the tendon were, therefore, about two inches and a half apart. The same obstacle to exact measurement existed at the upper extremity, from the intimate and gradual blending of the new and old tissues, as in the preceding specimen.

The appearances on section, &c., were in all respects similar to those of the preceding specimen.

Tendons divided by Open Wound.

Two experiments, exhibiting the process on the second and sixth days after operation. In these experiments the limbs were transfixed, and the tendons and integuments

divided transversely from within outwards. A compress of lint was applied, and the limb bandaged and allowed to remain undisturbed till the animal was killed.

Second day.—From a rabbit aged 4 months. The cutaneous wound had assumed an oval form in the axis of the leg, instead of retaining its transverse direction. This appeared to have resulted from the dropping of the os calcis, and the leg having been used. The wound measured very nearly an inch in length; its floor was formed by the glistening tendon of the posterior tibial muscle, and its edges were separated by clotted and dried blood. Scarcely a trace of blood existed beneath the skin, or beyond the edges of the wound; a little vascularity only was observable. The cut edges of the sheath were adherent to the edges of the cutaneous wound posteriorly, and anteriorly retained the firm connection which the sheath naturally has with the thin, but strong, sheath-like layer of fibro-cellular membrane investing the deeper tendons. Thus it was evident that, although the longitudinal continuity of the sheath had been interrupted by its transverse division, the effect of its natural relations anteriorly was to prevent any considerable separation, and, by the adhesions of its cut edges anteriorly with edges of the wound in its altered form, the longitudinal continuity was partially re-established. The transverse division of the sheath corresponded to about the centre of the now longitudinal cutaneous wound, and it was evident its divided edges had not retracted with the ends of the tendon.

The divided extremities of the tendon were an inch and three eighths apart, and both of them had the appearance of having retracted within the tubular sheath of the tendon. The lower extremity had in reality been drawn downwards from the seat of division by the use of the leg, but the

appearance, as regards the sheath and the wound, was the same as that of the actively retracted upper extremity. The cut ends of the tendon were square and abrupt, as if just divided. The sheath in the neighbourhood of the upper end was reddened by injection, and a small quantity of clot existed in its interior. At the lower end, very slight vascularity of the sheath existed; it was still pale; there was no evidence of inflammation, beyond the adhesion of the cut edges of the sheath to those of the cutaneous wound.

Sixth day. (From same rabbit. See Plate VIII, fig. 8.) —The cutaneous wound had assumed a completely longitudinal direction; it measured nearly an inch in length; its edges were separated about one eighth of an inch by dried adherent clot; its inferior angle extended a quarter of an inch below the inferior cut extremity of the tendon, which therefore was only covered by the clot, and the reparative process was entirely arrested at this part.

There were no appearances of inflammation, beyond the adhesion of the sheath of the tendon to the edges of the cutaneous wound, as in the preceding specimen. There was no extravasation of blood internally beyond the margins of the wound.

The divided extremities of the tendon were an inch and a quarter apart. The upper extremity had retracted a distance of five eighths of an inch above the superior angle of the cutaneous wound; through this space the reparative process had proceeded as favorably as in the subcutaneous section at the same period, but the new reparative material diminished in quantity at the upper angle of the wound, and from that point downwards, but little more than thickened sheath connected the divided extremities of the tendon; still this formed a continuous and tolerably

strong bond of union. The lower extremity of the divided tendon was surrounded by clot, extending downwards from the lips of the wound, the inferior angle of which extended a quarter of an inch below the cut surface of the tendon; its edges were smooth and rounded, and a small quantity of firm, fibrinous coagulum adhered to its surface; a little below its free extremity, the sheath, in a thickened condition, closely adhered to this portion of the tendon in its circumference, and anteriorly, or in its deepest portion, was continuous with the sheath connected with the upper extremity of the tendon, and the portion of new tendon formed in connexion with it. The longitudinal continuity of the sheath, which one might suppose to have been destroyed by its transverse division (some pains to ensure which were taken, not only by transfixing deeply, but by cutting transversely its deep connexion), was seen in this specimen to have been completely re-established. It appears that the sheath does not retract with the divided ends of the tendon, either in the open wound or the subcutaneous section, and its connexion anteriorly with the sheaths of the deeper tendons prevents its complete loss of longitudinal continuity; after any transverse division, there will still be an angle of connexion on either side, where a process of the sheath passes between the deeper tendons; the vascular connexion of the apparently separated portion is therefore maintained, and the adhesion, which appears quickly to take place between the cut edges of the sheath and the edges of the cutaneous wound (which, as already stated, assumes the appearance of a longitudinal fissure), at once re-establishes the longitudinal continuity of the sheath.

CHAPTER III.

GENERAL SUMMARY OF THE REPARATIVE PROCESS.

The results of the present experiments appear to confirm Mr. Paget's account in most respects, especially with regard to *the influence of blood, and the inflammatory process* in interfering with, rather than in assisting, the reparative effort; and, also, with regard to the development of the new connective tissue from a proper reparative material, described by Mr. Paget as "nucleated blastema," and differing from inflammatory lymph, in which fibro-cellular tissue is developed from nucleated cells.

Influence of the blood.—From these experiments it appears that blood is neither necessary nor advantageous to the reparative process; and that where it does exist, it interferes with rather than assists this process; a conclusion at variance with the opinions of Von Ammon, Pirogoff, Gerstaecker, Thierfelder, and Boner, but agreeing with that of Mr. Paget.

In those which I considered to be the best specimens, no blood whatever escaped from the wound, and no swelling of the part followed the operation. On the following day, the abrupt extremities of the divided tendon could easily be felt in the leg, generally about an inch apart, and the connecting sheath could be put on the stretch by extreme flexion of the foot, though not to become as prominent as the tendon.

From day to day this thin connecting membranous sheath

could be felt to become thicker and more cord-like, and on the sixth or eighth day it acquired the bulk and cylindrical form of the old tendon. At this period, or a little earlier, a defined enlargement of the lower extremity of the old tendon was felt, which increased till about the sixteenth or eighteenth day, and then gradually diminished. It was evident that this was not the result of inflammation following the operation, but belonged to the reparative process; a slight enlargement could generally be detected at the upper extremity also.

In examining these specimens on the first, second, third, and fourth days, only a very small and unimportant quantity of extravasated blood was found,—a thin streak of blood perhaps, within the sheath, and a film of coloured fibrin adherent to one or both of the cut extremities of the tendon, generally the upper. If extravasated blood be supposed to be the material from which the new tendon or connective tissue is formed, then the reparative effort must have failed in those instances which the series of experiments led me to consider as presenting the most favorable conditions for rapid and perfect repair. To obtain such specimens, the operation must be performed with great care; the rabbit held very firmly, the tendon divided low down (half an inch from its insertion), and a small and sharp knife used, which must be introduced and kept as close as possible to the tendon. I divided the tendon from before backwards.

In other instances, and those which I considered to be less perfect, a little bleeding followed the wound; and in one case a considerable subcutaneous effusion of blood immediately took place, but this did not occur in any other operation. In several instances, however, a little effusion was found to have occurred by the next day, and, upon examination, a clot of blood was seen in these cases, generally within the sheath,

not filling it, but occupying its central or lower portions. On the fourth or sixth day this blood-clot usually presented an oval, or circular, and well-defined outline ; and, except in one instance, on the tenth day was surrounded by inflammatory exudation, and was in process of softening and extrusion. At a little distance from these clots, both above and below, but more especially above,—in consequence of the greater distance to which the upper extremity of the tendon is always retracted,—the reparative process was seen proceeding as in the more perfect specimens, viz., by the formation of a cylindrical bond of new material, contrasting very strongly with the portion in which the disturbing influences existed.

It was evident that, wherever clots of blood existed, the reparative process was interfered with to a corresponding extent, as represented in Plate VIII, fig. 4.

In one specimen, on the tenth day, an elongated clot of blood was found in the centre of the new connecting bond, but simply enclosed, and without exhibiting any disposition to organization. The attenuated extremity of this clot appeared to have prevented the complete closure of the cutaneous puncture into which it extended.

Influence of the inflammatory process.—Inflammation appears, from these experiments, to be neither necessary nor advantageous to the reparative process; an opinion also agreeing with that of Mr. Paget. In many instances there were no indications of inflammatory exudation having taken place, or not more than enough to close the cutaneous puncture, and cause *very* slight adhesion of the sheath to the edges of the wound, the parts exhibiting only slight injection. There was no general infiltration of the tissues, rendering them succulent and yellow, like parts infiltrated in anasarca, as described. Vascularity of the sheath,

however, always existed during the activity of the reparative process, but not as an inflammatory condition. Where an excess of inflammation existed,—generally associated with some extravasation of blood,—the different conditions of inflammatory exudation, softening of fibrin, and the normal development of the new connective tissue, were all to be seen in juxtaposition, and might easily lead to error, unless the appearances were interpreted by comparison with a number of more perfect specimens.

Thus, from the appearances presented to the naked eye alone, these experiments have led me to the conclusion, that the rapidity and perfection of the reparative process is directly in proportion to the absence of both extravasated blood and inflammation.

In a few instances, an excess of inflammatory exudation took place without extravasation of blood; in these, the space between the divided extremities of the tendon was swollen by the third day, the swelling also extending below this point. On examination, the definition of the sheath, described in the other specimens, was lost in the general infiltration and effusion of lymph.

Influence of the sheath.—From these experiments, the influence of the sheath of the tendon, which in the subcutaneous operations is never completely divided, and often is but very little injured, appears to be of primary importance, not only in maintaining a direct connexion between the separated extremities of the tendon, and forming the matrix in which the reparative material is infiltrated in the first stage of the reparative process, but in determining from the beginning its direction and definite form. (See Plate VIII, figs. 1, 2, and 3.)

On the second day (Plate VIII, fig. 1), where neither extravasated blood nor inflammation follows the operation, the sheath forms an empty tubular connexion between the divided ends of the tendon, and is slightly thickened by infiltration of blastematous material among its fibrous elements. On the fourth day (fig. 2) the tubular character of the sheath is nearly obliterated by the increased thickening and succulency of its walls. The vessels of the sheath are injected; but there is not necessarily any evidence of inflammation. The sheath is infiltrated a little beyond the cut extremities of the tendon, which it therefore incloses and externally thickens. On the sixth day (fig. 3) a solid bond of union connects the divided extremities of the tendon, with which, however, it has but a very slender connexion. The extremities of the old tendon can be easily separated, or, as it were, enucleated. In this material the sheath is lost, its fibrous elements mingling with the new connective tissue abundantly at its circumference, and gradually diminishing towards the centre; but, so far as I could discern, without any definite arrangement such as described by Thierfelder, who says that processes of the sheath pass in between the three portions in which (imitating the old tendon) the new connective tissue or bond is formed. Except in cases in which excessive inflammation followed the operation, it did not appear to me, as described by Mr. Paget, that "a single well-defined and cord-like bond of union thus gradually formed, where at first there had been a uniform and seemingly purposeless infiltration of the whole space left by the retraction of the tendon." In those described as the more perfect specimens, the sheath appeared from the first to form the matrix, and determine the direction and form of the reparative material. To this, I think, we must attribute the great strength which the new connecting

bond soon acquires. Mr. Paget found that a tendon, which had been divided six days previously, sustained gradually increased weights up to ten pounds; and one of ten days, fifty-six pounds.

At a late period of the reparative process, when the new connecting bond has assumed a more perfect character, the formation of a new sheath on its surface may be traced, gradually separating, as it were, and becoming more distinct from the new tendon. In these experiments this process was seen to be advancing on the fifty-fourth day (fig. 7).

The experiments in which the tendons *were divided by open wounds* were made chiefly to ascertain how far the influence of the sheath was destroyed by this mode of operating; and it appears that complete transverse division by open wound does not destroy the influence of the sheath, as has been supposed, because it does not retract as the divided ends of the tendon do;—it must be observed that the lower extremity of the tendon is drawn downwards, away from the cutaneous puncture, in rabbits, by the use of the limb. The retraction of the sheath appears to be prevented mainly by its connexion with the processes of fascia, which extend between, and form the sheaths of, the deeper tendons; and in part also by its slender cutaneous connexions. There is no subcutaneous fat and cellular tissue in this situation in the rabbit, as in the human subject. Moreover, the continuity of the divided sheath appeared, in these experiments, to be quickly re-established by adhesion taking place between its cut edges and the margins of the cutaneous wound, which did not retain its transverse form, but in three or four days assumed a longitudinal direction, and on the sixth day appeared as if it had been a longitudinal incision (fig. 8).

The separation of the divided extremities of the tendons in these experiments, and consequently the length of the new reparative material or connecting bond, varied from an inch and a quarter to two and a half inches. This appeared to depend less upon the age and size of the rabbits (the ages varied from four months to a year and a half) than upon the time which had elapsed since the operation. Immediately after the operation, the separation was generally one inch. From the fourth to the twelfth day, it was generally an inch and a quarter. From the sixteenth to the twenty-sixth day, it varied from an inch and a half to an inch and three quarters. On the fifty-fourth day it was two inches; and on the sixty-second day it was two inches and a half. The last two specimens were from the same rabbit, aged four months at the time of operation, and the increased length in one leg appeared to depend upon an attenuated condition of the new connecting tendon in its central portion, probably from excessive use. This condition also existed in two or three other instances, in which the length of the new tendon was beyond that of the other specimens examined about the same period.

The divided extremities of the old tendon cannot be recognised externally, because the sheath is thickened and infiltrated for an eighth of an inch or more beyond the cut edges, which it serves to connect above and below. At a late period, however, the line of separation between the old and new tendon can be more distinctly recognised, by a slight difference in colour and vascularity.

In a longitudinal section, the extremities of the old tendon remain very distinctly obvious up to a late period; but this distinction, as an abrupt transverse line, is lost much earlier at the upper than at the lower extremity. On the twenty-sixth day, in these experiments, the blending

of the old and new tendon at the upper extremity was sufficient to render the exact line of junction somewhat indistinct. This increased to the fifty-fourth day, when the line of junction, as a distinct transverse line, was lost by a process of dovetailing of the new material with the separated fibres of the old tendon. The divided extremity of the lower portion was still square and distinct, though a fine dovetailing of the new and old tissues was apparent.

I did not detect any succulency or enlargement of the ends of the old tendon in the early stage of the reparative process, as described by Mr. Paget. An enlargement in the situation of the divided extremities of the old tendon was apparent externally; but this depended upon the thickening of the surrounding portion of the sheath, and might be described as analogous to the provisional callus in certain fractures (Plate VIII, figs. 3 and 4), but this appearance is not delineated so distinctly as it was seen in several specimens. This spurious enlargement gradually disappeared, and was succeeded by a true bulbous enlargement of the extremities of the old tendon, depending upon the separation of its fasciculi and the insertion of the new reparative material between them, by a process of dovetailing and intimate adhesion (see fig. 5). This also disappeared in the late stage.

Up to the sixth day (fig. 3) both the extremities of the old tendon appeared, on section, to remain passively included in the connective tissue, without undergoing any change, beyond a little rounding of their cut surfaces and slight diminution in firmness, not amounting to softening. They had but a slender connexion with the surrounding tissue. On the eighth day, the adhesion between the extremities of the old tendon and the new connective tissue was too close to admit of easy separation. On the

tenth day, the process of enlargement, by the separation of the fasciculi of the old tendon and insertion of the new reparative material between them, was seen to commence in the lower extremity. On the twelfth day (fig. 4), this was very distinct in the lower, and the commencement of the same process of enlargement was seen in the upper extremity. On the sixteenth day (fig. 5), this bulbous enlargement was more advanced in both extremities, but existed to a much less extent in the upper. On the eighteenth day this process was at its maximum, but remained much less at the upper than the lower end. The free extremities of the separated fasciculi slightly converged during this process, the new material existing in greater abundance a little beyond the cut extremities of the fasciculi; hence the bulbous form. On the twenty-second day, a perceptible diminution of this process was observed in both extremities; and it had still further advanced on the twenty-sixth day (fig. 6), when the line of separation between the old and new tendon at the upper extremity had become less distinct, from a more intimate blending of the tissues. On the fifty-fourth day (fig. 7), all appearance of this bulbous enlargement had disappeared from both extremities, which had resumed their cylindrical form. The exact line of separation between the old and new tendon was very indistinct above, but still traceable below. The process of union of the new with the old tissues was therefore more rapid and more easily effected at the upper, than at the lower, extremity of the divided tendon.

The general appearance of the connective tissue was in part given when we described its formation by infiltration of the new reparative material, between the fibrous elements of the sheath; which sheath, as we said, is but partially divided in the subcutaneous section, and, when completely

divided by open wound, does not retract, but has its continuity, to a certain extent, quickly re-established.

The connective tissue, or, as it may be called in reference to the later stages of its development, the new tendon, forming the bond of union between the divided extremities of the old tendon, preserved, to the latest period embraced in these experiments, viz., the sixty-second day, a degree of translucency which made it readily distinguishable from the opaque, white, glistening structure of the old tendon. Up to the eighth day, it presented a slight ruddy tinge, and was, in many instances, blotched with blood in its central portion, which appeared to result from the inclusion of the small quantity of extravasated blood within the infiltrated sheath, upon the vascularity of which the ruddiness also partly depended. The vascularity was most conspicuous at its circumference. This colour gradually diminished, and from the twelfth to the sixteenth day, it became uniformly of a grayish, translucent appearance, which it preserved in all the specimens of a later date. Simultaneously with this diminution of colour, the new tendon increased in toughness, but retained its homogeneous appearance till the twenty-second day, when a longitudinally striated or indistinctly fibrous character began to appear. This became more obvious on the twenty-sixth and fifty-fourth days (figs. 6 and 7), especially when a little extension of the tendon was made; but it did not acquire, even at the sixty-second day, a distinctly fibrous character obvious to the naked eye.

In these experiments the new material did not appear to be effused in greater abundance in the neighbourhood of the upper, than of the lower extremity, except in cases in which the extravasated blood or inflammation interfered with the reparative process.

At the latest period to which these experiments extended —viz., the sixty-second day—there was no evidence of any process by which the divided extremities of the original tendon might be brought into contact, and a linear cicatrix be formed, which is said by Mr. Tamplin[1] to be the result in the human subject, after division of the tendons for the cure of deformities. Mr. Tamplin's statement is not confirmed by my own dissections in the human subject, the result of which exhibit appearances very similar to those described in the late stages of these experiments on rabbits.

Microscopical examination.—In treating this part of the question, writers have been led into great confusion, from the fact that they have not properly distinguished between the reparative processes *per se* and the materials employed to effect pure reparation on the one hand, and the possible complications on the other hand. I have already explained that the reparation of tendons, like all other processes for the reparation of injuries, may be complicated by the presence of blood extravasated at the time of the injury, and by inflammation, which may come on afterwards.

Now, if specimens are taken indifferently, without regard to the fact whether the reparative material is or is not mixed with blood, or with inflammatory exudation, or with both, then a vast number of cell-forms, such as those which fill the plates of Thierfelder, may be described, and may be assumed to take part in the regular and essential reparative process.

On the other hand, if specimens are selected exhibiting the best and most perfect examples of newly formed con-

[1] 'On the Nature and Treatment of Deformities,' London, 1846, p. 8.

nective tissue, it will be seen that this variety of form is not necessary; on the contrary, that it is an accidental accompaniment; and that it indicates circumstances which do not promote, but interfere with and retard, the true reparative process.

If portions are taken from specimens in which clots of blood exist, generally in a softened condition, surrounded by inflammatory exudation, &c., then we should examine only such portions as are the furthest removed from the neighbourhood of these disturbing influences, viz., close to the ends of the old tendon; and from the central, rather than the circumferential, portions of the connecting material. In these portions only, will the appearances be found identical with those of the more perfect specimens.

If portions are taken from other specimens, in which extravasated blood may be absent, but in which excessive inflammatory exudation has taken place—rendering the sheath and adjacent cellular tissue succulent, so as to fill up the gap, and give the appearance of a thick and irregularly defined, cord-like bond of union, larger than the tendon itself, and lying between its divided ends, as occasionally seen from the third to the sixth day—the appearances will be such as are generally found in plastic inflammatory exudations; and even in the central portions, near the ends of the old tendon, granular corpuscles, and irregularly oval, caudate, and spindle-shaped cells, frequently of large size, will be seen diffused among the old fibrous tissue of the sheath, which can be at once recognised; small, elongated cells, or free nuclei, will also be seen in the finely molecular basis-material effused, and free oil-globules are abundant in proportion to the proximity to the centre of the inflammatory action.

Such specimens in the present series of experiments, sometimes presented externally more the appearance of rapid repair, than those in which little or no inflammation followed the operation; but it was evident, from the naked eye and microscopical examination of numerous specimens, that the reparative process was really less perfect.

To avoid all such sources of error, I selected for microscopical examination the specimens which I considered to be the most perfect, viz., those in which extravasated blood and inflammatory products existed in the smallest quantity; those in which, by the sixth day, a cylindrical bond of union was formed, of the size of the tendon itself, or perhaps somewhat less in its centre, having a defined outline, free from adhesions to the skin, except of the most delicate kind, and without thickening of the connecting layers of fibro-cellular tissue, or of the sheaths of the deeper tendons, to impede its free motion; in fact, resembling the tendon itself in all but colour. In such specimens, very little was seen of the plastic-exudation appearances above described.

Microscopically examined, the material infiltrating the sheath at its upper and lower extremities, on the second day, presented a homogeneous or a very minutely molecular appearance; and on the third or fourth day, nuclei, having a tendency to elongate, were visible in the meshes of the old sheath. These nuclei were more numerous and more distinctly elongated on the fifth and sixth days, but they could not be distinctly seen, or brought into view in any numbers, without acetic acid. The basis-material simultaneously acquires a tough, membranous-like texture; a portion removed by the scissors could be spread out, but would not tear or split into fibres; its edges tore only in flattened fragments. The fibrillation of this material

appeared to be a slow process. On the tenth day it was more separable, and on the sixteenth day its edges split into delicate filaments, generally short, but well defined. At this period the nuclei were seen to be much elongated, and more or less perfectly arranged in parallel lines, as in the healthy tendon. The basis-material also presented a delicate, fibrous structure. These appearances became more distinct in the later stages, and were best seen on the fifty-fourth and sixty-second days. During the action of acetic acid, the direct continuity of the nuclear fibres could be seen; but after the full action of the acid this continuity was seldom distinct, and could not be preserved; the appearance of the elongated nuclei, in parallel lines, was then as represented in vol. vi, plate xviii, of the 'Pathological Society's Transactions,' which appearances were drawn from these specimens.

Now, by these experiments it has been shown, that divided tendons in the rabbit become re-united by a newly formed connective tissue, which gradually assumes the structural characters of the old tendon so perfectly that, under the microscope, little or no difference can be perceived; in fact, a perfect reproduction of tendon takes place, and this new tendon may be formed of the length of two inches. In external form, definition, and size, it precisely corresponds to the tendon which it unites; and externally the continuity becomes after a few months so perfect, that the line of junction cannot be recognised. On a longitudinal section, however, the line of junction of the old with the new tendon, can be recognised at the latest period to which these experiments extend, viz., the sixty-second day; and I may here remark that I have found this equally apparent in a human tendon three years after division. The old tendon retains its opaque, dense, white, glistening character;

while the new tendon possesses a certain amount of translucency, and is of a uniformly grayish colour, without the characteristic glistening appearance of the old tendon. The mode of connexion by the finest dovetailing of the old and new tissues I have described.

APPENDIX.

A RÉSUMÉ OF THE ENGLISH AND FOREIGN LITERATURE OF THE REPARATIVE PROCESS IN TENDONS AFTER DIVISION EITHER BY SUBCUTANEOUS OR OPEN WOUND.

With references to such experiments performed on Animals, and Post-mortem Examinations in the Human subject, as have been recorded.

Hunter,[1] 1767? (probably about this date).—In 'The Life of J. Hunter,' by Drewry Ottley, prefixed to Palmer's edition of Hunter's works, it is stated that, in the year 1767, Hunter ruptured his tendo Achillis whilst dancing, and this accident led him to examine into the process by which divided tendons are re-united. "He divided the same tendon in several dogs, by introducing a couching-needle under the skin at some distance from it, and killed the dogs at different periods to see the progress of the union, which was found to be similar to that of fractured bones where the skin is not wounded. It was ascertained at Mr. Hunter's death, that the union of the ruptured tendon was by ossific deposition."

[1] 'The Works of John Hunter, with Notes by J. F. Palmer,' London, 1837, p. 34.

In 'The Works of Hunter' referred to, there is no account of these experiments, nor can I find any record of the recent appearances presented by the tendon operated upon; but in the Hunterian collection in the Royal College of Surgeons, there are five specimens of divided Achilles tendons from the ass and deer,[1] which were described by Mr. Paget, by whom the catalogue was prepared. Three of these specimens, it is believed, were divided subcutaneously, and two by open wound. Two of the former are described as follows:

No. 349.—"A longitudinal section of the tendo Achillis, and of part of the os calcis, of an ass. The tendon was divided transversely, and, it is believed, by subcutaneous section. Its divided extremities have retracted to a considerable distance from each other, but are united by a firm and compact substance, pale, though vascular, and presenting no appearance of a fibrous texture. A similar substance is diffused among the immediately adjacent tissues. (Hunterian specimen.)"

No. 352.—"A longitudinal section of the tendo Achillis of a deer, which, it is believed, was divided transversely by subcutaneous section, and in which the process of union has made further progress than in any of the preceding specimens. The uniting medium is not distinguishable from the tendon itself, except by being less glistening, by its fibres being less regularly parallel and longitudinal, and by its surfaces being united with the surrounding fibrous textures. (Hunterian specimen.)"

It is to be regretted that there is no further record of these experiments, nor in 'The Works of Hunter' is there

[1] 'Descriptive Catalogue of the Pathological Specimens in the Museum of the Royal College of Surgeons,' Nos. 348 to 354, London, 1847.

any account of the views entertained by him of the nature of the reparative process in tendons after division.

In 'Hunter's Works,' vol. i, chapter xv, under the headings of "*Union of a broken tendon;—rupture of the tendo Achillis;—principles of treatment, &c,*" the mode in which rupture of this tendon generally occurs, and the principles of treatment, are alone described; but from the statement made by Mr. Ottley, as well as from the appearances presented by the specimens themselves, there can be no doubt that Hunter divided the tendons both by subcutaneous and open wound, a fact of great importance in reference to the history of subcutaneous surgery, the fundamental law of which was first established by Hunter.[1]

Delpech, 1816,[2] 1823,[3] and 1828.[4]—Delpech made the first great step in advance towards the perfection of subcutaneous tenotomy by diminishing the size of the external incision, though he divided the skin on each side of the tendon, by transfixing with a scalpel to the extent of an inch.

Delpech also laid down some excellent rules for the after management of such cases (published in the year 1828, in

[1] See 'Sketch of the Principles and Practice of Subcutaneous Surgery,' by W. Adams, London, 1857.

[2] On the 9th of May, 1816, Delpech divided the tendo Achillis upon his improved method, *i. e.* without direct exposure of the tendon by open-wound—in the first, and the only case, in which he performed this operation. The case was one of talipes equinus in a boy, aged 19 years, and is related in the 'Chirurgie Clinique.' Suppuration and exfoliation of the tendon took place, but the case ultimately did well, and the boy was enabled to walk with very little lameness.

[3] 'Chirurgie Clinique de Montpellier,' tome i, p. 184, Paris et Montpellier, 1823.

[4] 'De l'Orthomorphie,' Paris, 1828.

his 'L'Orthomorphie,' twelve years after he had performed the operation), embodying the principle of maintaining the apposition of the divided extremities of the tendon immediately after the operation, and then making gradual extension. He does not appear, however, to have performed any experiments on animals, with the view of ascertaining the nature of the reparative process; but upon observation of what takes place after accidental rupture of the tendo Achillis, he founded his theory of union by an intermediate substance, capable of extension before it becomes solidified. Delpech observes:

"As reunion can only take place by means of an intermediate fibrous substance (*une organization inodulaire*), we can and we should submit this, before it becomes solidified, to a gradual and careful extension capable of giving to it the length required by the shortened muscles."[1]

The accuracy of this observation, and the principle of treatment based upon it, is fully borne out by the experiments on animals, and the *post-mortem* dissections in the human subject, detailed in the present work.

Mayo, 1827[2] and 1837.[3] — No post-mortem examinations in the human subject are recorded, but for the purpose of investigating the reparative process in tendons after accidental rupture or division, Mayo performed experiments on dogs, dividing the Achilles tendons by open wound, and the following is the account of the reparative process given by him—

[1] De L'Orthomorphie, tome ii, p. 330.

[2] 'Outlines of Human Physiology,' by Herbert Mayo, London, 1827.

[3] See also the fourth edition of the same work, London, 1837, from which the account above given is taken (see p. 477). In all four editions the same account is given in almost the same words.

"Of union by callus.—When tendons or nerves, cartilages or bones, are divided or broken across, the process of their reunion, instead of resembling the adhesive process, has more in common with the growth of a cicatrix. The injured parts are repaired through the intervention of a third substance, the product of a change in the neighbouring cellular texture.

"If the tendo Achillis is examined in a dog forty-eight hours after division, upon removing the skin the subjacent cellular membrane that surrounds the tendon, appears loaded with coagulable lymph, and extravasated blood. Upon making a longitudinal section of the thickened substance, the cut ends of the tendon contained within it, are found to be about an inch apart, but connected together by means of coagulated blood and swollen cellular texture.

"If the tendo Achillis is examined seven days after division, the ends of the divided tendons are found united by an intervening substance of greater thickness than the tendon itself, that is readily separable from the skin and subjacent parts. Upon a longitudinal section being made, the intervening substance appears of a dark-red colour, firm, and to a certain degree elastic; it coheres in some parts firmly, in others slightly, with *the cut ends* of the tendon, but strongly and inseparably with *the cellular sheath* of the tendon, which is discoloured for some distance from the wound; so that either end of the tendon admits without much force of being displaced from a socket in the intervening substance.

"At seventeen days after division, the intervening substance (or callus, as it may be termed) is found diminished in thickness, and to be firmer, paler, and inseparably co-

herent with the cut ends of the tendon, the nature of which it gradually assumes.

"The redness which I observed the callus to have in the early stages of these experiments is to be considered as accidental. The only mode of dividing the tendon was to cut it. But this involved an external wound, and although that wound healed by adhesion, and allowed the tendon to unite as a ruptured tendon unites, still it necessarily involved effusion of blood, which infiltrated the cellular membrane."

Stromeyer, 1831,[1] 1834,[2] and 1838.[3]—It is to Stromeyer that we are indebted for the reintroduction of tenotomy upon an improved and scientific basis, embodying the true principle of the subcutaneous method of operating, and he is therefore generally regarded as the founder of orthopædic surgery, though he is himself willing to divide the honour, and give the larger share to Delpech.

Stromeyer's opinions on the union of tendon after division, like the opinions of Delpech, were not founded upon direct observation, since neither experiments on animals nor any post-mortem observations on the human subject are referred to. Both of these early writers relied upon what they observed, as to the manner in which the tendo Achillis united after accidental rupture, and their theoretical

[1] On the 28th of February, 1831, Stromeyer first divided the tendo Achillis by subcutaneous puncture in a case of non-congenital equino-varus in a boy, æt. 19. No inflammation followed. By gradual extension the deformity was cured in two months, and the boy allowed to walk with a steel support to the boot. ('Rust's Magazine,' Band xxxix, p. 195, 1833.)

[2] 'Rust's Magazine,' Band xxxix, p. 195, 1833, in which the case above referred to is detailed.

[3] 'Beiträge zur operativen Orthopadik,' Hanover, 1838.

explanation of this process was of course in accordance with the general pathology of the time at which they wrote.

Stromeyer generally admitted the explanation of Delpech as to the reunion of tendon by the development of an intermediate connective tissue, which I have now shown to be a reproduction of tendinous structure, but he believed that this new tissue was not formed of sufficient length to compensate for the shortening of the contracted muscles observed in many severe cases of deformity; and arguing upon this opinion, Stromeyer combined a physiological with a mechanical explanation of the way in which such cases of deformity are cured by the division of tendons. He appears to have believed that a dynamic influence results from the division of the tendon, *i. e.* the irritability of the muscle being temporarily diminished by the division of its tendon, its power of contraction is weakened, and any increase of it prevented. Stromeyer observes: "Delpech has laid it down as a rule, that we should promote the development of a connecting substance between the divided extremities of the tendon, sufficient to maintain the function of the muscle, and therefore we should not disturb the union of the cut ends of the tendon by too early extension. If this principle is useful for the safe performance of orthopædic operations, and is worthy to be borne in mind, it is nevertheless based upon the false assumption that the elongation of the shortened muscle is produced through the substance of the cicatrix. The amount of this substance of the cicatrix is too insignificant for that purpose.

"In some severe cases of talipes equinus the gastrocnemii are several inches shorter than in their natural condition, and in wry neck the sterno-mastoid may be shortened to the extent of several inches, yet, after the cure, the newly formed connecting substance is only a few lines in length.

The elongation of the muscle, therefore, must be effected at the cost of its vital power of contractility, and this brings us to the conviction that the incision does not only produce a mechanical but also a dynamic influence upon the muscle, and that by a temporary interruption of its irritability its power of contraction is weakened, and any excess of it is diminished. This view is confirmed by observations on healthy muscles whose tendons have been divided by accident."[1] Stromeyer then adduces the case of a medical man who ruptured his tendo Achillis, and walked about a few days afterwards. Seven years after the accident he walked about, dragging his leg after him like a paralytic man. Stromeyer therefore condemns the practice of making immediate extension after the operation.

Stromeyer considers that the exudation of blood between the ends of the divided tendon interferes with, rather than assists, the healing process. He believes that the coagulum will be absorbed, and a plastic exudation take place, which becomes solid, and unites the ends of the tendons by a fibrous or fibro-cellular tissue, having a white, glistening appearance, as described by Guenther, who made experiments on horses by cutting away an inch of the tendon, which was afterwards found to be reproduced. These experiments were made by open wound, and were followed by suppuration and granulation.[2]

Bouvier, 1836,[3] 1838,[4] 1858,[5] does not refer to any human post-mortems, but has performed experiments on

[1] 'Beiträge zur operativen Orthopädik,' p. 14.

[2] Ibid, p. 71.

[3] 'Mémoire,' 12th of September, 1836, referred to by Dr. Ch. Phillips, 'De la Ténotomie sous-cutanée,' Paris, 1841.

[4] Mémoire sur la section du tendon d'Achille dans le traitement des Pieds-bots,' Paris, 1838.

[5] 'Leçons cliniques sur les maladies chroniques de l'Appareil Locomoteur.' By M. le Dr. H. Bouvier, Paris, 1858.

animals. In his recently published work, 1858, he observes:

"Immediately after the section the two ends of the tendon leave a greater or less space between them, occupied by the fibro-cellular sheath of the tendon. This sheath wounded by the knife, forms a kind of cylindrical canal adhering to both ends" (of the tendon). (He refers to Pirogoff's plates, and to specimens in the anatomical museum of Paris.)

"It is in that covering, or investment, in which the remarkable phenomena of reparation take place, to be compared to the periosteum or perichondrium at the seat of fracture of bone or cartilage take place.

"This phenomenon of reparation comprises two periods: 1st.—The period of inflammation. 2nd.—The period of reunion.

"The period of inflammation is never absent. You will hear of assumed *organization immediate* of subcutaneous wounds without previous inflammation. All that has been said in this respect is nothing else than a romance.

"The inflammation is developed, as in all traumatic lesions of living tissues in warm-blooded animals, more or less rapidly after the section; later in paralytic subjects with a feeble circulation. In the ordinary cases this inflammation is only slight, and has nothing of the acute form. Its symptoms are, slight swelling in the sheath, a morbid sensibility, and a vascular injection at that part.

"The special effect of this inflammation is an abundant exudation of plastic lymph, of plasma. This organizable material is seen sometimes with the naked eye in the horse.

"All observers have seen it with the microscope in experi-

ments on dogs and rabbits. I have myself constantly met with it in a series of microscopical observations which I made with Mr. Mandl. This plasma, more or less distinct from the exudated blood, is found in the interior of the sheath, in its substance, on the surface of the ends of the tendon, and finally in all the neighbourhood of the subcutaneous wound.

"According to the period at which we examine it, it presents a different appearance. In fact, it presents transformations analogous to the blastema in the normal formation of cellular tissue. It increases slowly in consistence, is penetrated by vessels, becomes fibrous, and forms a junction with the ends of the tendon, and with the primitive tissue of the sheath, to which it gives an increased density.

"This is, then, the second period of the reparation. The plasma is organized, *i. e.*, new bond of connection is formed, united with the two tendinous extremities, which are swollen; this is a true tendinous callus. The swelling of the extremities disappears later, and cannot be distinguished. Yet in the examination of a section, including the tendon and the cicatrix, we see a line of demarcation between the new tissue and the tendon. The fibres of the first are grayish; having a nacrous appearance and glistening with tendinous fibres; they are not fasciculated in parallel lines, but finely interlaced in all directions.

"With the age, this cicatrix becomes more and more dense; it has been seen cartilaginous. At the death of Hunter, who ruptured his tendo Achillis fifteen years previously, the cicatrix was found bony."

Bouvier then refers to the phenomena of reparation in the other tendons after division, especially in the tibialis posticus and peronei, when situated in dense sheaths and

adjacent to the bones, as when behind the malleoli, conditions which he admits give rise to some peculiarities, though generally the reparative phenomena are analogous to those observed in the tendo Achillis. He refers especially to the liability of such tendons to contract adhesions to the adjacent bone and to one another, so that the gliding movements of these tendons may be impeded, and the action of their muscles interfered with, or even abolished. He also refers to the absence of the cellular tissue, or cellular sheath in tendons thus situated in the hand and foot; and consequent deficiency of reparative material, if a wide separation of the divided extremities should be produced, when the new material must be formed either from the ends of the tendon or the synovial sheath. He here alludes to the possibility of complete failure of union of the divided tendon which he had witnesssed in some experiments on dogs, referred to, and presented by him to the *Académie de Médecine,* in 1842.

Von Ammon.—1837.[1] No post-mortem examinations in the human subjects are given, but Von Ammon investigated the reparative process in tendons after subcutaneous division in a series of experiments on horses, and the animals were killed at periods varying from twenty-four hours to six weeks after the operation; three experiments were performed on rabbits, the animals being killed at different periods—from six to twelve days after the operation. In the experiments on rabbits, the subcutaneous method of operating was adopted, and is carefully described; and the experiments on horses were probably also performed by the subcutaneous operation, but this is not distinctly

[1] 'De Physiologia Tenotomiæ experimentis illustrata,' Dr. Fredericus Augustus ab Ammon, Dresdæ, 1837.

stated, and the symptoms were more severe than might have been expected. The appearances observed in six specimens (five from the horse and one from the rabbit) at periods varying from twenty-four hours to one month, are exhibited in plates.

From these observations, Von Ammon gives the following account of the reparative process in divided tendons.

"When a tendon is divided, the pain is trifling; no spasm takes place. The divided extremities of the tendon soon contract, so that a gap is produced; the contraction of the upper extremity of the divided tendon being greater than that of the lower extremity.

"The gap between the divided extremities of the tendon becomes filled with blood, which flows more from the superior than the inferior extremity of the divided tendon. This blood is soon converted into a firm coagulum, which becomes intimately connected with the surrounding parts, but more especially with the divided extremities of the tendon, which at this time present an appearance as if they had been tied round with a thread. Plastic lymph, of a white rather than a yellow colour, is soon effused from the cut surfaces of the tendon, partly beneath the coagulum, but chiefly from the adjacent tissues, and at once exhibits plastic action.

"By organization proceeding in this effused coagulable lymph, pyramidal and thread-like streaks of a white colour are produced; these are the first traces of the new tendinous structure; they usually proceed from each extremity of the divided tendon, and join in such a manner that the exact line of junction can hardly be distinguished. After this reunion has taken place, day by day the soft material increases, so that the tissue hitherto pulpy, becomes consolidated, and we soon see in the place of a mass of semi-

transparent lymph, a tissue very closely resembling tendon. Yet this substance is not true tendon; it differs from the natural condition of tendon, I would not say in such a manner that it has not the smoothness and even surface of tendinous tissue, but rather because the new tendinous mass appears in the beginning sanguinolent, and less compact than in the real tendon; and at a later period, because it presents a blueish colour. The functions of this new tendinous tissue are however the same as those of healthy tendon. The only thing to be remarked, is that from the beginning the movements are more limited, and this appears to depend partly upon the want of elasticity in the new structure, and partly upon its adhesion to the surrounding tissues. A short time is sufficient for the formation of this new tendinous structure; I think it may be formed in fourteen days."[1]

In this valuable treatise by Von Ammon, will be found references to the earlier surgical authorities who had described, with more or less precision, the process of healing of tendons in man and in animals after rupture or wounds, the regeneration of tendinous structure being sometimes spoken of.

Duval.—1837[2]—1843.[3] No post-mortem examinations in the human subject are recorded, nor are any experiments on animals referred to in detail, though there

[1] Op. cit., page 21.

[2] 'Bulletin de l'Academie Royale de Médecine,' tome premier, Paris, 1636, p. 408. Séance du 14 Fevrier, 1837, 'Mémoire sur la section du tendon d'Achille et la cicatrisation des tendons,' par M. Duval. The volume appears to have been dated 1836, because the proceedings reported commenced in that year, but those of 1837 are also included.

[3] 'Traité practique du Pied-bot.,' Paris, 1843, p. 326.

can be little doubt that such experiments were performed by Duval, who gives the following account of the process.

"As soon as a tendon is divided, the two ends are separated by the contraction of the muscle. Some hours after the operation, the neighbouring cellular tissue becomes inflamed; and twenty-four hours afterwards, this tissue is bathed in serosity, and presents to the naked eye an œdematous aspect. The skin takes part in this turgescence. Sometimes we find a collection of red substance, resembling a clot of washed blood, between the divided extremities of the tendon.

"From the cellular tissue surrounding the divided extremities of the tendon, arise filaments which go to the fibrinous matter, and *vice versâ*. This substance, however, is not always met with, but what is constant is the inflammatory condition of the cellular tissue during the first seven or eight days. Thirty-six hours after the section, the intermediate substance is already found to exist in the form of a fibrous membrane much more developed at the upper than at the lower end, and this explains the inequality of the protuberance we feel under the skin on the following and the second day after the operation.

"On the third or fourth day, the intermediate tissue acquires much more thickness, and becomes fleshy, presenting a dark-red colour in its centre, and a whitish appearance at its circumference.

"From the seventh or eighth day this tissue assumes the form of the tendon, and the tendinous organization of this substance commences from the circumference by the condensation of the cellular sheath, and proceeds towards the central portion.

"From the fifteenth to the twentieth day the organization of this substance becomes complete, the red colour

disappears, and the newly formed tissue becomes as solid and resistant as the tendon itself, from which it differs only in its colour, which is less white; and sometimes, also, its thickness is less."[1]

Duval in his work ('Traité practique du Pied-bot.') observes—"When a tendon is divided its fibro-cellular sheath is generally but little injured; the ends of the tendon retract and leave in this sheath an intermediate space in which blood and plastic lymph are effused and become organized. The plastic lymph is effused by the vessels of the sheath, which has become the seat of inflammatory action, congested and succulent, as if hypertrophied; and from its sides an abundant exudation takes place of the materials necessary for the work of reparation, so that the divided ends of the tendon take the least part in it."[2]

Dr. Little, 1837,[3] 1839,[4] 1853.[5]—No post-mortem examinations in the human subject, or experiments on animals, are referred to by Dr. Little, nor in any of the treatises above mentioned is there any account given of the nature of the reparative process in tendons after division. This subject does not appear to have been investigated by Dr. Little, but as it is to him that we are indebted for the introduction of subcutaneous tenotomy, and I may say, of orthopædic surgery, into this country,

[1] Op. cit. 'Bulletin de l'Académie Royale de Médecine,' Séance du 14 Fevrier, 1837.

[2] Op. cit. 'Traité practique du Pied-bot.,' Paris, 1843, p. 326.

[3] Diss. inaug. Symbolæ ad Talipedem varum cognoscendum. W. J. Little, Berolini, 1837.

[4] 'A Treatise on the Nature of Club-foot,' London, 1839.

[5] 'On the Nature and Treatment of the Deformities of the Human Frame,' London, 1853.

the omission of his name from the list of writers on this subject might have appeared to have been a strange oversight. I may here mention that, in June, 1836, Dr. Little, who was himself afflicted with non-congenital equino-varus of the left foot, arising from infantile paralysis, had the tendo Achillis divided by Stromeyer, in Hanover, and on the 20th of February, 1837, introduced the operation into this country, by dividing the tendo Achillis in London.

Guérin, 1838,[1] 1839,[2] and 1841.[3]—Guérin has not recorded any post-mortem examination in the human subject, nor does he refer in detail to any experiments on animals, though there can be but little doubt that he had performed such experiments with the view of ascertaining the nature of the reparative process in tendons after division.

In his published works above referred to, Guérin discusses generally the physiological explanation of the reparative process in subcutaneous wounds; and by the results of his operations, endeavours to illustrate and enforce the truth of the Hunterian law, with respect to the reparative process in wounds from which the air is excluded, viz., that, as a general rule, such wounds neither inflame nor suppurate; whilst wounds to which the air is admitted, as a rule, both inflame and suppurate.[4]

Guérin considers that a tendon divided by subcutaneous

[1] 'Mémoire sur l'Étiologie générale des Pieds-bots congenitaux,' Paris, 1838.

[2] 'Mémoire sur les Variétés anatomiques du Pied-bot congénital,' Paris, 1839.

[3] 'Essais sur la Méthode sous-cutanée,' Paris, 1841.

[4] For further illustration of this subject, see Adams on 'Subcutaneous Surgery,' London, 1857.

incision is united by an intermediate substance formed without appreciable inflammation. Essentially he regards the reparative process as depending upon the organization of plastic lymph. With regard to the disposition of any effused blood, Guérin considers that the more fluid portion of the blood is absorbed, and that the fibrinous portion remains coagulated, and afterwards becomes organized; taking some part, therefore, in the reparative process.

Velpeau, 1839[1] and 1851.[2]—No post-mortem examinations in the human subject, or experiments on animals, are referred to by Velpeau; but the following general account of the reparative process is taken from the American edition referred to, vol. i, page 400.

Velpeau observes: "The division of the tendons is followed by a process which differs, according as there exists at the same time a wound in the skin, or that the process takes place protected from contact with the air.

"A. *In contact with the air.*

"If the solution of continuity is at the bottom of an ulcer or a wound, the two ends of the tendon remain for a long time pale, like an inert substance (*tige*); ultimately, however, they become vascular, and covered with reddish granulations. These granulations, which encroach at the same time upon the surrounding cellular fibres (*feuillets*), are the point of departure and the termination of a vegetation, which results in filling up in part the void which the ex-

[1] Nouveaux elements de Médecine operatoire,' 2d edit., Paris, 1839.

[2] American edition of Velpeau's 'Operative Surgery,' by Dr. Townsend and Dr. Valentine Mott, New York, 1851.

tremities of the ruptured tendon leave between them. Here, then, the solution of continuity is cicatrized by second intention; cellular tissue, aponeurosis, vessels, subcutaneous tissue, and tendons, are all finally blended together in a single mass, which itself contracts intimate adhesions with the skin in the neighbourhood, &c.

"B. *Protected from contact with the air.*

"If the tendon is ruptured under the skin, or divided without any inflammation supervening, we must expect results of a totally different nature, but which vary according as the two ends of the tendon are kept in contact or remain apart. The agglutination of the tendon is effected either by first intention if the contact is perfectly exact, or, on the contrary, through the medium of a plastic matter, which, at first soft and gelatinous (*gélatiniforme*) soon assumes a lamellar and fibrous appearance. Blending itself with the tendon, this material is converted into a sort of kernel (*noyau*), or node (*nodus*), which itself rarely fails to disappear at the expiration of some weeks or months. Being neither stretched out, nor soldered (*soudé*), to the surrounding tissues, the tendon thus soon recovers all its primitive power and mobility.

"When there is a separation of several lines between the two ends, there occasionally takes place in that part an effusion of blood, of fibrine, or of plastic lymph. This effusion often becomes organized. Its liquid and colouring matters are gradually absorbed, the fibrine and plastic lymph harden as they become cemented to the two ends of the tendon, which they envelop in the manner of a ferule (*virole*). Afterwards, becoming transformed into fleshy tissue (*se carnifiant ensuite*), we may recognise, on the tenth

or twelfth day, an appearance of fibres, or of a substance like felt (*feutrage*), and an elasticity, which continues to increase. The final result is, that there is formed from this a portion of new tendon, which appears to have been created there for the purpose of giving greater length to the old tendon. It may readily be conceived, that from this period a part of the functions of the wounded tendon will be restored, but that its excess of length will not readily permit it to resume entirely, all the power it possessed in its normal state.

"When, with the separation which I have mentioned, the union of the teguments with the cellular tissue at the bottom of the division, has been effected before the effusion has taken place, and without any inflammation, the two ends of the tendon, if they are very far apart, cicatrize, separately, each one in its place, and remain without the new uniting medium (*sans lien nouveau*), and as if they were lost in the cellular tissue; the action of the corresponding muscles is lost, in this case completely destroyed.

"The knowledge of this process shows, at once, what we have a right to expect, and what is proper to do, when the continuity of a tendon has been interrupted."

It will be observed that the opinions of Velpeau refer essentially to union of the tendo Achillis after rupture in a healthy foot, and not to the mode of union after division for the cure of deformities. His observation that union by intermediate tissue, or new tendon, as he correctly describes it, interferes with the restoration of the functions of the muscle, are correct as regards healthy feet; but in the cure of deformities, the effect of the increased length of the tendon, is to increase the power of the muscle by furnishing the mechanical conditions which allow it to come into play.—W. A.

Pirogoff, 1840,[1] performed more than seventy experiments on dogs, sheep, calves, and fowls, by dividing the Achilles tendons subcutaneously, and observed the reparative process at different periods, from twenty-four hours to twelve months after the operations. In his admirable treatise on this subject—from which much appears to have been taken without acknowledgement by subsequent authors—twenty-one illustrations from his dissections are given.

Pirogoff describes the reparative process as proceeding by two distinct methods, depending upon the presence or absence of extravasated blood, an event which he says depends upon the mode of dividing the tendons.

If the tendon be divided from before backwards, the knife being introduced between the bone and the tendon, Pirogoff asserts that effusion of blood into the sheath of the tendon always occurs, and as he considers this to be essential to the perfection of the reparative process, he describes it as *the first method.*

If the tendon be divided from behind forwards, the knife being introduced between the skin and the tendon, he asserts that effusion of blood into the sheath of the tendon does not occur, and as he considers this to give rise to a less perfect mode of repair, he describes it as *the second method.*

Of the first method, *i. e.* with extravasation of blood, Pirogoff describes the following as the appearance from *twenty-four to thirty-six and forty-eight hours* after division of the tendons, page 18.

"1st. The sheath remains in animals as in man, un-

[1] 'Ueber die Durchschneidung der Achillessehne, als operativ-orthopædisches Heilmittel,' von Nikolaus Pirogoff, mit sieben Tafeln, Dorpat, 1840. For an account of these experiments, see also Gerstaeker's 'Diss.'

injured, except the small puncture which is plugged up by coagulum of the blood.

"2d. The skin can be separated but with more difficulty from the sheath of the tendon, than in the normal state. The thin cellular layer between the skin and the sheath, and the skin itself, are apt to become œdematous.

"3d. We find traces of extravasated blood in the cellular layer, and on the inner surface of the skin in the neighbourhood of the puncture.

"4th. The cellular sheath of the tendon is expanded by the extravasated and coagulated blood, generally more so in the central portion, and therefore it assumes the form of an olive; in some cases the coagulum can be easily removed from the sheath with the handle of the knife, but in other cases we find small portions of the blood adherent to the inner wall of the sheath, and in trying to remove them, white filiform exudations of plastic matter are found adherent to the sheath.

"5th. The internal surface of the sheath is uneven and reddish, and in some parts presents a dark red colour, evidently the result of imbibition.

"6th. The cut ends of the tendon are covered by coagulum, which at this part is more firmly adherent than on the internal surface of the sheath. After removing the coagulum, the cut surfaces of the ends of the tendon do not appear quite clear, but seem to be covered by exudations having a varnished appearance. I have observed these exudations principally on the lower ends of the tendon, after two days, in the form of small whitish bodies firmly adherent."

"*From four to seven and nine days.* 1st. The blood collected in the sheath is partly fluid, and in some cases we can, after exposing the sheath, distinctly feel fluctuation.

From the seventh to the eighth day the sheath looks blueish, and resembles a cyst, the coagulated portion of the blood being external, and the fluid portion internal. 2d. The sheath itself is thickened. 3d. To both ends of the tendon small conical blood-coagula are generally adherent, the tendinous structure of the cut surfaces remaining glistening and unchanged, except at the extreme points, which are covered by a thin layer of plastic material and blood-coagulum. 4th. Thread-like, whitish exudations are seen, scattered in the sheath round small masses of blood."

"*From ten to fourteen days and up to three weeks*, page 20, we observe: 1st. The sheath is much thickened (from two to three times thicker than in its natural state), and we distinguish with more difficulty the different layers of exuded plastic material on the walls of the sheath, which has a reddish-white colour. 2d. The inner surface of the sheath is of a dark-reddish colour, rough and uneven, covered with plastic exudation and the remains of coagula. 3d. Sometimes a canal is found (from fourteen days to three weeks) passing through the centre of the thickened sheath, and containing either fluid, dark-coloured blood, or lined by a yellow-reddish pseudo-membranous material."

"*From four to six weeks* up to two months the following appearances are observed. 1st. The canal in the middle of the new substance has disappeared, but after three or four weeks the central portion of the new substance appears to be of a darker red colour than the peripheral portion. 2d. The sheath of the tendon is completely strong, and blended with the ends of the tendon. 3d. The new connecting substance looks whitish on section, and forms a homogeneous tissue in which no fibres can be distinguished, and generally presents the cylindrical form of the tendon; sometimes it assumes the form of an olive; at its upper and lower

extremities, the new tissue penetrates between the fibres of the ends of the cut tendon. 4th. Blood-vessels can be demonstrated in the new substance by injection, and red points are observed in making the section."

"*From six to eight months*, page 21, the tendon feels hard in the neighbourhood of the operation, the firmest part being near the ends of the tendon. On making a longitudinal section of the tendon, its fibrous structure exhibits an absence of its natural brilliancy, and it is difficult to distinguish exactly the line of demarcation between the old and the new tissue. The new substance has not the true fibrous appearance of tendon, and looks more like the structure of cicatrices after amputation. Blood-vessels can be demonstrated by injection, and are more numerous towards the periphery."

Pirogoff divides the process of healing according to the first method into five periods, page 21.

"1st. The formation of coagulum in the sheath, and on the cut ends of the tendon.

"2d. Thickening of the sheath, with plastic deposits on its inner surface.

"3d. The progressive deposition of plastic matter on the walls of the sheath, and from the ends of the tendon, with the disappearance of blood-coagulum, and frequently with the formation of a canal in the middle of the new connecting substance.

"4th. The complete disappearance of the coagulum, and of the central canal, or the increased solidity of the sheath, with deposit of plastic material between the fibres of the cut ends of the tendon and their thickening.

"5th. The solidification of the new connecting substance, and of the material deposited between the fibres of the cut ends of the tendon."

Of the second method, *i. e.* without extravasation of blood in the sheath, Pirogoff observes, if we make a puncture between the skin and the tendo Achillis, and divide the tendon carefully from behind forwards towards the bone, whilst the leg is held in a flexed position, we can divide the tendon without causing extravasation of blood. The healing process in these cases he describes as follows.

"1st. *In the first few days*, but little change takes place in the sheath; it becomes somewhat thickened, particularly on its inner surface, and a small quantity of blood is adherent to the ends of the tendon.

"2d. By the approximation of the walls of the sheath, its central canal gradually diminishes, and entirely disappears in a few weeks.

"3d. The interspace between the ends of the tendon grows wider by the extension of the empty sheath, from the movement and flexion of the limbs.

"4th. The functions of the leg of the animal are never completely restored; at least so it always appeared to me in more than twenty cases. In two dogs, which lived six months, the interspace between the divided ends of the tendon, was increased to six inches by the flexions of the legs.

"5th. In examining *after a month or six weeks,* we find the interspace generally from two to two and a half inches in length, and after three months often four inches. The connecting sheath has the form of two cones with the points applied to each other, and the bases of the cones in contact with the ends of the tendon. The longer the interspace, the thinner seems the cord formed by the sheath, and in the middle we can hardly distinguish it from the neighbouring cellular tissue; it may be compared with an obliterated process of the peritoneum; near to the cord we can distinguish traces of fibrous tissue in its substance, which

have their origin in the thickening of the walls of the sheath; the cord is whitish in colour.

"6th. A remarkable appearance in the process of union, is the very strong and knobby form of the thickening of the ends of the tendon; this thickening is always stronger here than in the first method; it is of cartilaginous hardness, and on the cut surface we see distinctly the plastic material deposited between the fibres of the tendon; we also sometimes see the continuation of this deposit in that part of the sheath which is in contact with the ends of the tendon.

"7th. The muscles connected with the upper ends of these tendons become shortened, atrophied, and pale.

"8th. The thickness and hardness of the new connecting substance, are in proportion to the quantity of extravasated blood in the sheath of the tendon. I frequently found the sheath only half filled with blood, and in these cases the connecting substance was neither so strong as in the first method, nor was it so totally wanting as in the second."

CONCLUSIONS.

Pirogoff observes (page 39), "On the whole, from the description of the healing process of the tendo Achillis above given, we may draw the following conclusions.

"1st. There are two methods of the healing process which are essentially different from each other.

"2d. The formation of a new connecting substance is the result of the first, the usual, method of the healing process. Isolated cicatrization of both ends of the tendon is the result of the second method.

"3d. The presence of extravasated blood in the sheath of the tendon is the *conditio sine qua non* of the formation of the new connecting substance.

"4th. In that case, the extravasated blood not only excites irri-

tation in the neighbouring parts necessary to provoke plastic action, but also acts as a material for the formation of plastic lymph.

"5th. This metamorphosis of the extravasated blood runs through different periods, which can be distinctly recognised.

"6th. The tendinous structure is not regenerated through the formation of the new connecting substance; but in its physical properties the new substance forms a perfect substitute for tendon.

"7th. The functions of the limb will be completely restored after the first method of the healing process. On the other hand, the extension of the limb will remain quite impossible after the second method of the healing process.

"8th. Not only the sheath, but also the ends of the tendon, take part in the formation of the new connecting substance; but the sheath always plays the most essential part.

"9th. In the second method of the healing process, the space between the divided extremities of the tendon, will gradually increase as the result of the continual flexion of the limb; on the other hand, in the first mode of union, the length of the new connecting substance remains always the same."

I have given Pirogoff's account of the reparative process in tendons more in detail than was originally intended, not only because it bears the impress of careful and original observation, but because it has been much relied upon by all subsequent observers, and appears in several instances to have influenced their interpretation of the phenomena observed. I need hardly say that the conclusions to which my observations have led me, are totally opposed to those of Pirogoff, though we are perfectly agreed as to many of the facts observed.

Dieffenbach, 1841.[1]—Dieffenbach does not refer to any post-mortem examinations on the human subject; or to any experiments on animals, with the exception of some experiments on the division of the muscles of the eye in

[1] 'Ueber die Durchschneidung der Sehnen und Muskeln,' Berlin, 1841.

rabbits. On the subject of the reparative process in tendons after division, he refers to the experiments of Von Ammon and of Prinz.

Dieffenbach, however, appears to be of opinion (see page 12) that the effusion of blood in subcutaneous operations is rather an obstacle to the reparative process. He considers that the effused blood acts as a foreign body, and must be absorbed.

Phillips, 1841.[1]—No post-mortem examinations in the human subject are referred to by Phillips, nor does he relate any experiments of his own, but quotes the opinions of authors already referred to.

Koerner, 1843,[2]—describes the anatomical appearances of the specimens of divided and reunited tendons from the horse, preserved in the museum of the veterinary school at Dresden, by Dr. Prinz, who performed the experiments.

In the description of the microscopical appearances of these specimens Dr. Koerner states—

"1st. That after fourteen days, he did not find in the connecting tissue a fibrous structure, but only small nuclei.

"2d. That after twenty-eight days, the connecting substance did not present a fibrous structure to the naked eye, though fibrous tissue was traceable under the microscope.

"3d. That after fifty-nine days, the appearances were similar to those in the last specimen, but the nuclei were smaller and more transparent.

"4th. That after sixty-seven days, fibres running in a parallel direction formed the principal appearance presented, the nuclei being few in number.

[1] 'De la Tenotomie sous-cutanée,' par le Dr. Ch. Phillips, Paris, 1841.

[2] Physiologische Streitfragen über den Heilungs process nach der Subcutaneal Tenotomie, 'Journal der Chirurgie und Augenheilkunde,' von Walter und von Ammon, Bd. 31, p. 262, 1843.

"5th. That after eighty days, the appearances were similar to those in the last specimen, the number of nuclei perhaps being increased."

Dr. Koerner also describes three experiments performed by himself on rabbits, in which he divided the Achilles tendons and removed portions of the sheath by open wound. The parts were examined at intervals of four, seven, and nine days. No suppuration occurred, though in one specimen on the fourth day, the existence of pus-globules appears to have been doubtful; coagulated blood and plastic lymph are described as existing at the seat of the operation, and on the ninth day a small canal is described in the middle of the new substance.

The description of these specimens does not appear to be very lucid, and they are of little value from the short time allowed to elapse before the animals were killed.

Tamplin, 1846.[1] Mr. Tamplin has recorded the post-mortem appearances in two cases in the human subject after subcutaneous tenotomy; one at eight and the other at twelve months after the operation. He observes:

"I have had two opportunities of examining the condition of tendon that had been operated upon during life, after death; the one was a boy, about seven or eight years of age, in whom the tendo Achillis was divided for complete talipes equinus, the heel being elevated to its full extent; he was of weak, delicate, and unhealthy constitution, and the foot was brought into position three or four weeks after the operation; the uniting medium was at the time nearly two inches in length, soft, yielding, and exceedingly weak.

[1] 'Lectures on the Nature and Treatment of Deformities,' London, 1846.

It gradually, however, strengthened, contracted upon itself, and became as strong, to all appearance, as the original tendon; nor could any irregularity or thickening be detected. Twelve months after the operation he was attacked with scarlet fever, of which he died. His father informed me of it, and offered to allow an examination. On examining it externally, no trace of its having been divided could be detected; it possessed the same prominent uninterrupted outline as its fellow; the point of puncture could with difficulty be detected. On removing the skin and cellular tissue, there was no evidence of a wound having been inflicted, no adhesions, thickening or swelling, and on laying open the sheath the tendon presented one uniform and natural appearance; so much so, that one was almost led to doubt the possibility of its having been divided. I then made a longitudinal section, but could discover no alteration with the naked eye, except a sort of globular appearance in one spot, but not sufficiently differing from the tendon itself to make us positive.

"'The other was a congenital case of talipes varus, in a child of eight months of age when operated upon; and who died from hooping-cough and head affection eight months after the operation. The tendo Achillis, the anterior and posterior tibial tendons, had been divided. The same perfection exists here, and, at the examination, no trace of any kind could be detected, in appearance, or by sense of touch. I was fortunate enough to obtain the tendon, which you can examine for yourselves."[1]

In the museum of the Royal College of Surgeons also, are the tendo Achillis and the anterior and posterior tibial tendons from a child, removed eighteen months after they had been divided for congenital varus, by Mr. Tamplin, and

[1] Op. cit., p. 9.

in these specimens it is said that no trace of the division and reunion could be detected, either by the naked eye or by the microscope. In the catalogue of the museum the following description is given of these preparations.

"The tendo Achillis, and the tendons of the anterior and posterior muscles of a child nineteen months old. They were all divided by subcutaneous section, nearly eighteen months before death. No trace of the division is discernible in any of them; their outlines and surfaces are regular, and their texture is uniform; even with the microscope no part could be found different from the rest." [1]

With regard to these last specimens I have already stated, at page 66, that they were not examined, when recent, by a longitudinal section, the only method by which, at a late period, the difference between the old and new tendon can be recognised—the new tendon always preserving an appearance of grayish translucency, which contrasts with the opaque pearly lustre of the old tendon. I have also demonstrated the very close resemblance between the old and new tendon in microscopic characters, so that it cannot be said that the absence of new connective tissue in these specimens can be considered as proved. Moreover, sections of these tendons were made by Mr. Quekett and myself, some time ago, and there appeared to me to be some indications of new tissue in the tendo Achillis, but the traces were obscure from the effect of spirit, so that it was impossible to give a positive opinion.

With regard to the nature of the reparative process generally, and the theory or the *modus operandi* of tenotomy in curing deformities, Mr. Tamplin supports the opinion of Stromeyer, who considered that because the newly

[1] 'Pathological Catalogue of the Museum of the Royal College of Surgeons,' vol. ii, Nos. 358, 359, and 360.

formed connective tissue did not appear to him to be long enough, to compensate for the shortening of the muscles in cases of severe deformity, division of a tendon must act not only on the mechanical but also on the vital properties of the corresponding muscle, and by diminishing its irritability, also diminish its contractile power. More than this, however, Mr. Tamplin believes that the new connective tissue undergoes a process of gradual contraction, and that ultimately it becomes completely absorbed, the muscular structure at the same time becoming elongated by the force of the contraction of the cicatrix, so as to allow of the re-approximation of the ends of the divided tendon, and the formation of a *linear cicatrix.*

Mr. Tamplin observes:

"It is true, as a general rule, that the cicatrix, after the cure is effected, measures but a few lines, oftentimes only a line, in the thickness, provided proper care has been taken during the treatment. In the foot, I have found the permanent cicatrix full two inches in length (after the operation of talipes equinus), and a worse distortion produced, viz., the talipes calcaneus valgus, where the foot was placed in position immediately after the operation, and kept for a long time in the flexed position; this position was not, however, maintained, except during the exercise of volition. The elongation in congenital cases, and also in non-congenital cases, of young subjects, is undoubtedly effected eventually at the cost of the contractility of the muscle, but not primarily: this is a second result, for no new uniting medium can by possibility possess the power of drawing down the muscle, any more than the newly formed granulations following a burn can do; the cicatrix, as it contracts, certainly does so, but after the foot is brought into position; and hence the *linear cicatrix.* The force of

the contraction of a cicatrix is sufficiently evident in the instances of burns alluded to, not only to draw down and overcome one muscle, but even a set of muscles—as the extensors of the head and neck, or of the arm, and other parts." [1]

Whilst these pages were passing through the press, a lecture has been published by Mr. Tamplin, in which he still continues to express his belief in this *linear cicatrix* theory, in the following terms. "I have had many opportunities of examining the muscles after death of patients whose tendons had been divided during life; and in none could I trace the slightest difference between these and the muscles which had been contracted. I would here remark, that the union of the tendons which had been divided some few months, was most perfect—a linear cicatrix being alone visible. This is most satisfactory, as serving to show that division of the tendon does not destroy its integrity, excepting during the time immediately following the operation, *provided the necessary precautions are taken,* viz., keeping the parts perfectly at rest, and as far as is possible placing the divided ends of the tendon in juxtaposition. In slight cases proceeding slowly and cautiously with the after-treatment, or the power of contraction, which is common to all cicatrices, from whatever cause they may originate, becomes destroyed, and a worse deformity is produced.

"This was the principle laid down by Delpech, the author of this operation, based as it now is upon scientific principles; and it is a principle which can in no case be departed from without incurring great risk." [2]

[1] 'On Deformities,' p. 8.

[2] A Course of Lectures 'On the Nature and Treatment of Deformities,' by R. W. Tamplin, 'Brit. Med. Journal,' June 16, 1860.

This is the theory which has also received the sanction of my colleagues, Messrs. Brodhurst and Coote, and I will here only observe that all my experiments on animals, and dissections from four days to three years after tenotomy in the human subject, now recorded, as well as the experiments on animals made by other observers, are totally opposed to the idea of the temporary nature of the new connective tissue and this *linear cicatrix* theory.

Paget, 1849,[1] and 1853.[2]—No post-mortem examinations in the human subject are recorded by Mr. Paget; but the general pathology of the reparative process in tendons after division by subcutaneous and open wounds was investigated by him, "in a series of numerous experiments performed with the help of Mr. Savory, on rabbits from three to six months old." Mr. Paget first observes, "such experiments are, I know, open, in some measure, to the same objection as I showed in the last lecture to those on fractures in the lower animals; but the few instances in which examinations have been made of human tendons, divided by subcutaneous section, have shown that the processes in man and in animals are not materially different. The chief differences are, we may believe, that, as in the repair of bones, the production of reparative material is more abundant, and its organization more speedy in animals than in man." Then with regard to the differences in the results after division of the tendons by open and subcutaneous wounds, Mr. Paget states the disadvantages of dividing the

[1] 'Lectures on Surgical Pathology,' delivered at the Royal College of Surgeons in 1849, and published in 'Med. Times and Gaz.,' of 1849.

[2] 'Lectures on Surgical Pathology,' vol. i, London, 1853, from which the quotations now made are taken.

Achilles tendons by open wound to be—the liability to inflammation in the neighbourhood of the wound, and suppuration between the retracted ends of the divided tendon; adhesions between the tendon and the skin, and a liability of the retracted ends of the tendon to become displaced, so that their axes may not exactly correspond. Such mishaps, however, were found to be rare when the open wounds were quickly closed, and long-continued exposure to the air avoided. Of these cases Mr. Paget observes:

"The same cases of speedy healing of the opening in the integuments, served to show, that it is unimportant for the healing of divided Achilles tendons whether the cellular sheath or covering of the tendon be divided or not. In all the cases of open division in these experiments, it was completely cut through, yet when the external wound healed quickly, the union of the divided tendon was as speedy and as complete as in any case of subcutaneous division in which it might be supposed that the sheath of the tendon was not injured."

Mr. Paget then gives the following account of the reparative process in tendons after their subcutaneous division, as observed by him in the rabbit (see page 268).

"I have already said that very little blood is effused in the subcutaneous operations. Commonly, only a few blotches of extravasation appear in and near the space from which the upper part of the tendon is retracted. The first apparent consequence of the division of the tendon is the effusion of a fluid or semi-fluid substance, which, like the product of common inflammation, quickly organizes itself into the well-known forms of lymph or exudation-cells. These speedily becoming more distinctly nucleated and elongated, undergo the changes which I mentioned in describing the development of cells in granulations. The

exuded lymph makes tissues at and near the wound, succulent and yellow, like parts infiltrated in anasarca. The blood-vessels near the divided tendon enlarge, as in an inflamed part, and appear filled with blood. The exudation, together with the enlargement of the vessels, swells the parts, so that the skin is scarcely at all depressed between the separated ends of the tendon. But in well-made subcutaneous sections this inflammatory product is of small amount, and takes, I believe, little or no share in the healing of the injury; for the exudation ceases after the first twenty-four hours, and I think that its cells are not developed beyond the state in which they appear spindle-shaped. I have never seen indications of their forming filaments of cellular or fibrous tissue.

"In rabbits, forty-eight hours usually elapse before there are distinct signs of the production of the proper reparative material. This is deposited in the fibro-cellular tissue that lies between and close round the separated ends of the tendon, as well as in the interspaces of the tendinous fasciculi of those ends. It thus swells up the space between the separated ends, and makes the ends themselves larger, and somewhat ruddy, soft, and succulent. Some portion, at least, of it being deposited where the inflammatory effusion was, one finds their constituents mingled; but I believe that, while the proper reparative material developes itself, the product of the inflammation is either arrested in its development, or even degenerates, its cells shrivelling and gradually wasting.

"I need not now describe the mode of development of the reparative material provided for divided tendons, for I have taken it as a typical example of the development of lymph into nucleated blastema, and thence into fibrous tissue (p. 269). To the naked eye it appears after three

days as a soft, moist, and grayish substance, with a slight ruddy tinge, accidentally more or less blotched with blood, extending from one end of the tendon to the other, having no well-marked boundary, and merging gradually into the surrounding parts. In its gradual progress, the reparative material becomes commensurately firmer, tougher, and grayer, the ruddiness successively disappearing from the circumference to the axis: it becomes, also, more defined from the surrounding parts; and, after four or five days, forms a distinct, cord-like, vascular bond of connexion between the ends of the tendon, extending through all the space from which they have been retracted, and for a short distance ensheathing them both."

"As the bond of connexion thus acquires toughness and definition, so the tissue around it loses its infiltrated and vascular appearance; the blood-vessels regain their normal size, the inflammatory effusion clears up, and the integuments become looser, and slide more easily. In every experiment one finds cause for admiration at the manner in which a single well-designed and cord-like bond of union is thus gradually formed, where at first there had been an uniform and seemingly purposeless infiltration of the whole space left by the retraction of the tendon.

"With the increase of toughness, the new substance acquires a more decidedly filamentous appearance and structure. After the fourth day, the microscope detects nuclei in the previously homogeneous fibrine-like reparative material; and after the seventh or eighth day there appear well-marked filaments, like those of the less perfect forms of fibrous tissue. Gradually perfecting itself, but with a rate of progress which becomes gradually less, the new tissue may become at last, in all appearance, identical with that of the original tendon. So it has happened in the

valuable specimens presented to the museum of the College by Mr. Tamplin. They are the Achilles tendon and the tendons of the anterior and posterior tibial muscles of a child nine months old, in whom, when it was five months[1] old, all these tendons were divided for the cure of congenital varus. The child had perfect use of its feet after the operation, and, when it died, no trace of the division of any of the tendons could be discerned, even with microscopic aid.

"In the instances of divided human tendons, less retraction, I have already said, takes place than in those of lower animals. The connecting bond is therefore comparatively shorter; and it is yet more shortened when, like a scar, it contracts as it becomes firmer. It is impossible, therefore, to say what length of new material was, in this case, formed into exact imitation of the old tendon. But, however little it may have been, such perfect repair as these specimens show is exceedingly rare. More commonly, the differences between the original tendon and the new substance remain well marked. The latter does not acquire the uniform arrangement of fibres, or the peculiar glistening thence accruing to the normal tendons; it is harder and less pliant, though not tougher; its fibres appear irregularly interwoven and entangled, dull-white, like those of a common scar. And these differences, though as time passes they become gradually less, are always seen when a longitudinal section is made from behind, through both the ends of the tendon and the new substance that ensheaths and connects them. In such a section one

[1] The dates here given do not correspond with the dates given in the 'Pathological Catalogue of the Museum of the Royal College of Surgeons,' vol. ii., Nos. 358, 359, 360.

sees each of the retracted ends of the divided tendon, preserving nearly all its peculiar whiteness, only somewhat rounded, or misshapen, swollen, and imbedded in the end of the new substance, which is always grayer or less glistening, and looks less compact and regular. In the retracted ends of the tendon one may discern the new substance mingled with the old, and interposed between its fasciculi, with which one may believe it is connected by the finest dovetailing." [1]

Gerstaecker, 1851.[2]—No post-mortem examinations in the human subject are recorded, but the reparative process in tendons after subcutaneous division was investigated by Gerstaecker in a series of experiments, (fourteen in number,) on rabbits, and the animals were killed at different periods varying from twenty-four hours to two months after the operations.

After describing the experiments in detail, Gerstaecker gives the following summary of his own opinions at page 25, in which he appears essentially to agree with Pirogoff.

"From these experiments it appears evident to me that the regeneration of tendon proceeds by two methods, very different from each other, one of which may be described as the true, and the other the false regeneration.

"The true regeneration depends upon the extravasation of blood; the blood is not only effused from the cut surfaces of the tendon, but also from the subcutaneous vessels, into the sheath of the tendon, where it soon

[1] The appearances are shown in specimens in the College museum, Nos. 348 to 354; and in those from the experiments on rabbits in the museum of St. Bartholomew's.

[2] 'Dissertatio de Regeneratione Tendinum post Tenotomiam,' Adolphus Gerstaecker, Berolini, 1851.

coagulates, so that the wound in the sheath as well as that in the skin is plugged up. In the first few days, the internal surface of the skin,[1] and also the sheath of the tendon, are the seat of a more or less severe form of inflammation; in the interspace between the divided extremities of the tendon a fluctuating tumour is observed; the cut surfaces of the tendon are covered with serous exudation. The commencement of the process of regeneration is observed in the peripheral part of the blood-coagulum; thirty or forty hours after the operation, this part of the coagulum not only begins to assume a paler colour, but also acquires an increased solidity; soon after this, whitish fibrinous fasciculi, at first very thin, but afterwards thicker and more numerous, are formed in this part. These fasciculi, although they are adherent to the sheath of the tendon yet take their origin very little from it; which some authors dispute; but at the same time also, the cut surfaces of the tendon become adherent to the sheath by fasciculi running transversely to those formed at the periphery. As the process of regeneration advances, the blood-coagulum is changed by degrees, from the circumference towards the centre, into fibrous tissue; and in an equal degree, not only the transverse fibres from the periphery, but also those which take their origin from the divided surfaces. But after a longer time the coagulum becomes so far changed into a fibrous cord, that only a central canal is preserved, passing from one end of the tendon to the other, rather narrowed in the middle, and

[1] This expression is not incorrect, as regards the rabbit, in which animal there is no subcutaneous fat or cellular tissue in the neighbourhood of the tendo Achillis, as in man, and for this reason it is more easy to demonstrate the sheath of the tendon in the rabbit; and to observe the changes which occur in this structure.

filled with a little serous coagulum. But when this coagulum is also changed into fibrous tissue the central canal is entirely filled up, so that the intermediate connecting substance is formed into a solid fibrous cord. At the same time the ends of the tendon appear to be very much thickened, whilst the fibrous tissue is transformed into the tendinous structure. Henceforward the tendon is easily distinguished from the new substance, which is entirely wanting in the white colour, the fine structure, and the silver lustre, and is very similar to the tissue of cicatrix.

"The false regeneration takes place when no blood is effused into the sheath of the tendon from the subcutaneous vessels, and only a small quantity is effused from the cut surfaces of the tendon, in consequence of which the sheath appears collapsed. But when the internal surface of the sheath exhibits inflammation depending upon the lesion, the sides will soon be found to be in contact, so that it resembles a flat band. The cut surfaces of the tendon are surrounded and covered by a small quantity of blood, which, as in the true regeneration, is changed into fibrous tissue, and each of the ends of the tendon unites separately with the sheath; afterwards these ends themselves appear to be swollen. But when the regeneration is completed according to this method, it is clear that the sheath of the tendon is wanting in all its solidity, the interspace between the ends of the tendon increases daily, so that the effect of the muscle is destroyed."

At page 35, Gerstaecker gives the following as the general conclusions at which he has arrived from the observations and experiments which he has recorded.

"1. There are two methods by which the regeneration of the tendon takes place.

"2. The false regeneration takes place only when there is no blood effused in the sheath of the tendon.

"3. The true regeneration depends upon the blood effused in the sheath.

"4. The greater part of the blood is effused from the subcutaneous vessels, and the smaller portion from the cut surfaces of the tendon.

"5. The intermediate substance is developed neither from the divided extremities of the tendon, nor from the sheath, but is formed directly from the metamorphosis of the blood."

Thierfelder, 1852,[1] performed experiments on thirteen rabbits, dividing the Achilles tendons in each animal subcutaneously, and making the examinations at periods varying from twenty-four hours to fifty-six days after the operations. He arranges the specimens described in two classes, according to the appearances presented, viz., in the first class, those examined from twenty-four, forty-one, and forty-eight hours, and after four and six days, and in one case after nine days, which he says exhibited a large quantity of fluid effused in the sheath and surrounding cellular tissue, in some cases mixed up with blood-coagulum; and in the second class those examined after nine days, in which the sheath was completely filled up by a solid substance, without the least vestige of fluid.

From the general account given by Thierfelder (at pages 2 and 14), it seems that he considers the new reparative material to be developed from the fluid, described as serum, containing blood-corpuscles in greater or less abundance effused in the sheath and surrounding cellular

[1] 'Diss. Histol. de Regeneratione Tendinum,' F. F. Thierfelder, Misenæ, 1852.

tissue (inflammatory lymph ?), and from the blood-coagulum, found principally within the sheath; but the blood, he appears to think, plays the principal part in the formation of the new tendon.

In describing the microscopic appearances of the fluid, he states, that red blood-corpuscles, more or less abundant, are suspended in a transparent, colourless, or a little yellowish liquid, and also describes oil-globules and molecules as contained in this fluid. The further development of oval, elongated, spindle-shaped or fusiform cells, is then described as taking place in the fluid, and also in the blood-coagulum. The form, size, and measurements of these cells are carefully given. Thierfelder's chief examinations, indeed, relate to the cell-forms in the exuded fluid and the solid connecting bond. The cells and new fibres in the tissue around the bond are, he says (page 16), irregularly placed, while those in the bond are parallel with its long axis.

The close connexion of the bond with the former sheath he ascribes (p. 16), generally to the infiltration of the exuded formative material taking place among the elements of the sheath, but says that in many cases, processes of the sheath pass in between the portions in which, imitating the old tendon, the bond is formed.

Thierfelder gives the following conclusions at page 17:

"1st. The circumference of the leg is diminished after the section of the tendon, especially at the bend of the knee.

"2d. Every tendon becomes about one eighth shorter after the operation (by the recoil of its divided parts ?).

"3d. The retraction after division is about twice as great in live rabbits as in dead ones.

"4th. The divided and reunited tendons are about two thirds longer than the undivided."

Boner,[1] 1854, performed upwards of thirty experiments on rabbits, by dividing the Achilles tendons subcutaneously, and describes two distinct methods of union, viz., with and without effusion of blood.

If no effusion of blood follows the operation, he says, "the empty sheath of the tendon falls in, and the space between the divided extremities of the tendon appears as a depression when examined externally." He describes an interval varying from three to five lines (German measure) as existing between the cut ends of the tendon.

"If we examine this space carefully after a few days, we observe that the ends of the tendon and the sheath are swollen, and that numerous vessels pass through and ramify on the ends of the tendon, the material around which appears to be red and thick.

"Now an effusion of plastic lymph takes place not only around the ends of the tendon, but also in the sheath, which is injected by a network of vessels; and the inner walls of the collapsed sheath become adherent, not only to the ends of the tendon, but to each other, so that the whole is converted into a thin solid cord. In this case the interval between the ends of the tendon will be almost twice as great as it was immediately after the operation, and the function of the limb will be permanently disturbed, and no complete cure will take place." He cites Pirogoff and Thierfelder as agreeing in this opinion. In describing the other process, he observes:

"*But if there is effusion of blood*, which can easily be seen, as a little generally flows through the puncture, the interval between the ends of the tendon is not only filled up, but is

[1] Die Regeneration der Sehnen, J. H. Boner, 'Archiv. für Pathologische Anatomie und Physiologie und für Klinische Medicin,' von R. Virchow, p. 162, Berlin, 1854.

bellied and vaulted. The effused blood soon coagulates, and organization of this coagulum will take place; a result which did not once fail to occur in more than thirty cases."

Boner then proceeds to describe the process of organization of the blood-coagulum, noticing the disappearance of the blood-corpuscles on the fourth day, and the development of round cells with large nuclei. These cells are described as becoming gradually elongated and flattened, and the nuclei also becoming "oblong, almost in the form of a spindle." He also notices that the continuity of the elongated extremities of the cells can sometimes be traced. After the eighth or tenth day, he says, "the intercellular substance exhibits a fibrous appearance, which from that time becomes more distinct, and gives to the coagulum more and more the appearance of a tendon. Therefore we have, about the end of the second week, complete organization of the coagulum and the formation of tendinous tissue, but the normal firmness of the tendon is only acquired after the fourth week, or sometimes later.

Brodhurst, 1856[1] and 1859[2].—No post-mortem examinations in the human subject are recorded by Mr. Brodhurst, but he refers to experiments on rabbits in which he divided the Achilles tendons subcutaneously. No minute account of the reparative process is given in the work on club-foot referred to, but generally he appears to agree with Mr. Paget, except with regard to the influence

[1] 'On the Nature and Treatment of Club-foot,' p. 101, London, 1856.

[2] A communication to the Royal Society, Nov. 4, 1859, 'On the Repair of Tendons after their Subcutaneous Division.' An abstract only of this paper has at present appeared in 'The Proceedings of the Royal Society,' No. 37, 1860, and is given in the following pages.

of the sheath, as to which he confirms the results of my experiments published in the 'Trans. of the Path. Soc. of London,' vol. vi, London, 1855, and now represented.

Mr. Brodhurst's attention appears chiefly to have been directed to the possibility of obtaining union of the divided extremities of the tendon without intermediate tissue, so as to produce a *linear cicatrix*, which Mr. Tamplin believes to be the result of the division of tendons in the human subject, when applied to the treatment of deformities, and followed by gradual mechanical extension. In these experiments of Mr. Brodhurst, therefore, the rabbits' legs were rigidly fixed in splints and bandages, which were allowed to remain till the animals were killed. Mr. Brodhurst observes: "I endeavoured to divide the tendons in the same manner as in man, and afterwards to keep the limb at rest, and the articulation motionless."

Under this treatment it was found that whilst the ends of the tendon were separated to one inch immediately after the operation, this space was diminished to three fourths of an inch on the third day; half an inch on the sixth day; and a quarter of an inch on the eleventh day. Mr. Brodhurst then observes: "Each day added to the strength and perfection of the intermediate substance (the acmé of its perfection being its total disappearance? W. A.); also, its length gradually diminished, until a slight bulbous enlargement of the tendon alone marked the point of division. At the end of the tenth week, or from that time to the third month, this enlargement had disappeared, and the point of union was only appreciable on making a longitudinal section of the tendon; a very small cupped depression marked the point of division of the tendon. These examinations were continued from day to day for three months, and they tend to confirm the opinion entertained by Mr.

Tamplin and others, of the gradual contraction of the new uniting bond, until a cicatrix alone remains; which, also, is subsequently removed, and is not to be traced even by microscopic aid."[1]

Abstract of Mr. Brodhurst's paper, 'On the Repair of Tendons after their Subcutaneous Division,' as published in the 'Proceedings of the Royal Society,' vol. x, *No.* 37, 1860. *This paper was sent to the Society on the* 4*th of November,* 1859, *and read on the* 15*th of December,* 1859.

"The results of the experiments which are recorded by the author are divided into three classes, which tend to show—

"1st. That a tendon having been divided, may reunite without leaving permanently a cicatrix.

"2d. That the uniting new material may be drawn out to any required length, and in such case may, under gradual and carefully regulated extension, even acquire the thickness of the tendon itself; but that, if the divided ends are widely separated after the section, and so remain, reunion will not take place.

"3d. That the addition of new tendon does not impair the strength of the muscle, unless the length be more than sufficient, in which case it occasionally weakens the muscle.

"The process of reunion is explained, and the appearances presented by the tendon in the various stages of reunion are detailed and illustrated by coloured drawings. Preparations of the parts operated on were also exhibited. The author concludes that, when the divided ends of the tendon are held in apposition, and the limb is kept at rest, reunion

[1] 'On the Nature and Treatment of Club-foot,' p. 101—104, London, 1856.

will take place without leaving a cicatrix; but that when extension is made, the new material becomes organized, and persists as a permanent structure."[1]

With regard to the process of union in tendons divided in the human subject for the cure of deformities, Mr. Brodhurst observes, at page 96, in his work on club-foot:

"If the tendons of the retracted muscles in a child with congenital varus be divided, and allowed to reunite, and the limb be gradually reduced to its normal direction, it is found, when extension has been made gradually and carefully, that the new bond of union slowly contracts, so as to leave no outward mark on the tendon itself of the incision which had been made. On dividing the tendon longitudinally, a slight depression may be observed in its centre, corresponding to the section which was made; but this is also in time removed, so that, in fact, no mark is left of the section and reunion of the tendon.

This I have verified, both in the infant and in animals.

[1] With regard to the possibility of obtaining direct or immediate union of the divided extremities of a tendon, so as to lead to the production of "*a linear cicatrix*," there can be little doubt that such a result may be obtained, when by bandages, splints, or other mechanical contrivances, the divided extremities of the tendon are retained in direct apposition long enough for the process of union to take place, as in the treatment of a ruptured tendon; but I would observe the object of inquiry connected with our present subject ought to be, not how divided tendons reunite when exact apposition is maintained; but how they unite when the divided extremities are separated, as they must necessarily be to a greater or less extent, after operations performed on the human subject—such as the division of the tendo Achillis—for deformities of the feet, which, after this operation, are restored to their natural position, by gradual mechanical extension, whether gradually or rapidly applied.—W. A.

In the latter, in the course of three months, it is not possible to affirm which of two Achilles tendons had been divided. When, however, blood has been effused, or inflammation excited, a longer time is required entirely to obliterate the cicatrix and the central depression."[1]

Holmes Coote, 1858.[2]—My colleague, Mr. Holmes Coote, has contributed to our knowledge of the present subject, by recording the recent appearances presented by two Achilles tendons which had been subcutaneously divided at periods of two and three months previous to the death of the patient. Mr. Coote observes—

[1] It is much to be regretted that statements so broad and comprehensive as the above, should not have been accompanied by additional proof of post-mortem dissections in the human subject—especially as they are said to have been verified in the infant—but no such dissections are referred to. Of course we cannot regard the experiments on animals as compensating for this deficiency, since the conditions must be totally dissimilar. We have no club foot in the rabbit to begin with, nor can muscles under any circumstances be supposed to be in a condition similar to those in the club-footed leg of an infant.

I can only observe, that the general account given by Mr. Brodhurst, and also by Mr. Tamplin, of the reparative process in tendons divided in the human subject, is totally at variance with all the results of my dissections in the human subject, at periods from four days to three years after the operation, as described and figured in the present work.

In all my cases, I would further remark, that the after-treatment was conducted upon the orthodox plan of gradual mechanical extension commenced after the third day, and continued during a fortnight or three weeks, a period usually sufficient for the formation of the required length of new connective tissue in healthy children. In paralytic cases, and in patients of feeble health, this time should be doubled.—W. A.

[2] 'Medical Times and Gazette,' January 9, 1858.

"I have lately had the opportunity, through the kindness of my colleague, Mr. Tamplin, of examining two specimens of subcutaneously divided tendo Achillis taken from the same subject, the one operated on three months, the other rather less than two months, before the death of the patient.

"Case.—An undersized man, æt. 38, suffering from lateral curvature of the spine, and talipes equinus of both limbs, a cripple, unable to put his feet to the ground, was admitted in the month of August, 1857, into the Royal Orthopædic Hospital, under Mr. Tamplin. The right tendo Achillis was divided August 27th, the left September 30th. Scarpa's shoe was applied to both feet, and the heels were well brought down by the end of the present month (November). On the 23d of November, the influenza being then prevalent, he was seized with cough and cold. Pneumonia of both lungs rapidly ensued; he lay restlessly upon the right side until the 26th, when he rapidly sank, and expired about six in the afternoon.

"The examination of the body, which was performed by Mr. Pocklington, detected consolidation of the right lung, and a great amount of secretion in the bronchial and pulmonary tubes of the left. With these post-mortem appearances, however, I do not wish to interfere. The divided tendons, with the newly formed connecting tissues, were removed, and to these attention was particularly directed, inasmuch as no instance is, I believe, at present on record of the examination of such parts, as seen in the adult, two or three months after operation.

"The right tendo Achillis was adherent to its sheath.

"It presented the usual pearly white colour. The surrounding vessels, especially the veins, were full and

tortuous. The external fibrous investment was complete and of usual appearance; but between the two extremities of the tendon there was a compressed portion *two inches in length*, the transverse measure of which, as compared to the obviously normal part, was as two eighths to three eighths of an inch. A longitudinal incision through the tendon showed an interval of just two inches between the divided ends of the normal tendo Achillis, which were united by a light gray semi-transparent structure, through which were traced, well formed, opaque, pearly white fibres, passing from one extremity to the other of the cut tendon. The new tissue was clearly defined from the old, being of a totally different colour; the opaque white hue of the normal structure standing out in strongly-marked relief. After drying for a short time, the new tissue acquired a rosy tint, obviously due to the blood contained in numerous capillaries.

"The interval between the cut extremities of the left tendon did not exceed *one inch and a half*. The transverse measurement was the same as in the preceding specimen; but along the sheath there were numerous patches of extravasated blood. The opaque white fibres of the original tendon were separated in parts at their junction with the newly formed tissue, which appeared in the interspaces, and were dove-tailed. Towards the lower end of the connecting medium, near its junction with the calcaneal portion of the tendo Achillis, there was an oval cyst half an inch in length, containing dark fluid blood.

"The examination of the newly formed tissue under the microscope exhibited some points of interest. It contained a large proportion of oil-globules intimately mingled with the firmer and more fibrous material. The latter consisted of granular matter, and of newly formed fibres of ill-

defined contour; yet exhibiting in many situations the appearance of being formed of elongated nuclei, for at the broken edge of the specimen numerous loose nuclei were seen floating about free, or united in linear series of three or more. There were some whiter and more opaque parts among the newly formed tissues; these closely resembled, but did not quite equal in clearness or in contour, the normal white fibrous tissue of histologists.

"The specimens here described are interesting as contrasted with others, of equal value, presented by Mr. Tamplin, to the museum of the Royal College of Surgeons. These were the tendo Achillis, and the tendons of the tibialis posticus and anticus muscles of a child nine months old, in whom, at the age of five months, these tendons had been divided for congenital varus. The child had perfect use of its feet before death, and when it died no trace of an operation could be detected even by microscopical examination.[1]

"The question here suggests itself—Does the absence of abnormal appearances in the tendons of the infant arise from the gradual conversion of the connecting medium into white fibrous tissue? or, does the connecting tissue con-

[1] The age and date of operation stated by Mr. Coote in this case are the same as in Mr. Paget's 'Lectures,' vol. i, p. 270, but some mistake appears to have occurred, as in the 'Pathological Catalogue of the Museum of the College of Surgeons,' vol. ii, these dates are very differently stated, as follows:

"Nos. 358, 359, 360.—The tendo Achillis and the tendons of the anterior and posterior tibial muscles of a child nineteen months old. They were all divided by subcutaneous section nearly eighteen months before death. No trace of the division is discernible in any of them; their outlines and surfaces are regular, and their texture is uniform. Even with the microscope no part could be found different from the rest."

tract so as ultimately to approximate the ends of the divided tendon, and form a "linear cicatrix"?

"I must confess, that in the specimens before me, there is the very faintest approximation of normal appearances in the connecting tissue. The divided ends of the tendo Achillis seem imbedded in a soft pulpy mass of quite different consistence and colour. The absorption of the oily and soft material would have reduced this structure to at least one third its present bulk; and it would have acquired the appearance of a narrow cord. I am not, therefore, prepared to acknowledge, that the newly formed tissue gradually acquires so much of the properties and of the external characters of tendon, as to be with difficulty distinguishable. On the contrary, it would rather seem that a slow process of approximation is effected between the cut ends, and that this is combined with an altered sphere of muscular action.

"It may be urged, in opposition to this view, that the interval between the cut extremities of the first divided and consequently more completely repaired tendon, was longer than that of the opposite. It must be remembered, however, that no great length of time had elapsed since the operation—scarcely three months; and that in all probability twelve months would be required for the completion of all the processes of repair in an adult."

The facts recorded by the examination of these specimens in the recent condition are of themselves valuable, but I cannot agree with Mr. Coote in considering that they in any degree support the *linear cicatrix theory*, when the new connecting tissue measured an inch and a half in one tendon two months after its division, and two inches in the other tendon three months after its division. The supposition that a process of absorption of the oily and

soft material was going on, and that this might be completed in a twelvemonth, so that a reapproximation of the divided extremities might be considered as likely to take place; and that combined with this an altered sphere of muscular action would result, so that the function of the muscle might be restored when the *linear cicatrix* was complete—appears to me to be an explanation not supported by any facts adduced. Moreover, such an explanation is entirely opposed to all the ascertained facts recorded in the present work.

J. E. ADLARD, PRINTER, BARTHOLOMEW CLOSE.

By the same Author.

A SKETCH

OF

THE PRINCIPLES AND PRACTICE

OF

SUBCUTANEOUS SURGERY.

London, New Burlington Street,
June, 1865.

MESSRS. CHURCHILL & SONS'

Publications,

IN

MEDICINE

AND THE VARIOUS BRANCHES OF

NATURAL SCIENCE.



"It would be unjust to conclude this notice without saying a few words in favour of Mr. Churchill, from whom the profession is receiving, it may be truly said, the most beautiful series of Illustrated Medical Works which has ever been published."—*Lancet.*

"All the publications of Mr. Churchill are prepared with so much taste and neatness, that it is superfluous to speak of them in terms of commendation."—*Edinburgh Medical and Surgical Journal.*

"No one is more distinguished for the elegance and *recherché* style of his publications than Mr. Churchill."—*Provincial Medical Journal.*

"Mr. Churchill's publications are very handsomely got up: the engravings are remarkably well executed."—*Dublin Medical Press.*

"The typography, illustrations, and getting up are, in all Mr. Churchill's publications, most beautiful."—*Monthly Journal of Medical Science.*

"Mr. Churchill's illustrated works are among the best that emanate from the Medical Press."—*Medical Times.*

"We have before called the attention of both students and practitioners to the great advantage which Mr. Churchill has conferred on the profession, in the issue, at such a moderate cost, of works so highly creditable in point of artistic execution and scientific merit."—*Dublin Quarterly Journal.*

Messrs. Churchill & Sons are the Publishers of the following Periodicals, offering to Authors a wide extent of Literary Announcement, and a Medium of Advertisement, addressed to all Classes of the Profession.

THE BRITISH AND FOREIGN MEDICO-CHIRURGICAL REVIEW,
AND
QUARTERLY JOURNAL OF PRACTICAL MEDICINE AND SURGERY.

Price Six Shillings. Nos. I. to LXX.

THE QUARTERLY JOURNAL OF SCIENCE.

Price Five Shillings. Nos. I. to VI.

THE QUARTERLY JOURNAL OF MICROSCOPICAL SCIENCE,

Including the Transactions of the Microscopical Society of London.

Edited by Dr. Lankester, F.R.S., and George Busk, F.R.S. Price 4*s*. Nos. I. to XVIII. *New Series.*

THE JOURNAL OF MENTAL SCIENCE.

By authority of the Association of Medical Officers of Asylums and Hospitals for the Insane. Edited by C. L. Robertson, M.D., and Henry Maudsley, M.D.

Published Quarterly, price Half-a-Crown. *New Series.* Nos. I. to XVII.

THE JOURNAL OF BRITISH OPHTHALMOLOGY
AND
QUARTERLY REPORT OF OPHTHALMIC MEDICINE AND SURGERY.

Edited by Jabez Hogg, Surgeon. Price 2*s*. 6*d*. No. I.

ARCHIVES OF MEDICINE:

A Record of Practical Observations and Anatomical and Chemical Researches, connected with the Investigation and Treatment of Disease. Edited by Dr. Lionel S. Beale, F.R.S. Published Quarterly; Nos. I. to VIII., 3*s*. 6*d*.; IX. to XII., 2*s*. 6*d*., XIII. to XV., 3*s*.

ARCHIVES OF DENTISTRY:

Edited by Edwin Truman. Published Quarterly, price 4*s*. Nos. I. to III.

THE ROYAL LONDON OPHTHALMIC HOSPITAL REPORTS, AND JOURNAL OF OPHTHALMIC MEDICINE AND SURGERY.

Vol. IV., Part 3, 2*s*. 6*d*.

THE MEDICAL TIMES & GAZETTE.

Published Weekly, price Sixpence, or Stamped, Sevenpence.

Annual Subscription, £1. 6*s*., or Stamped, £1. 10*s*. 4*d*., and regularly forwarded to all parts of the Kingdom.

THE HALF-YEARLY ABSTRACT OF THE MEDICAL SCIENCES.

Being a Digest of the Contents of the principal British and Continental Medical Works; together with a Critical Report of the Progress of Medicine and the Collateral Sciences. Post 8vo. cloth, 6*s*. 6*d*. Vols. I. to XL.

THE PHARMACEUTICAL JOURNAL,

Containing the Transactions of the Pharmaceutical Society.

Published Monthly, price One Shilling.

*** Vols. I. to XXII., bound in cloth, price 12*s*. 6*d*. each.

THE BRITISH JOURNAL OF DENTAL SCIENCE.

Published Monthly, price One Shilling. Nos. I. to CV.

THE MEDICAL DIRECTORY FOR THE UNITED KINGDOM.

Published Annually. 8vo. cloth, 10*s*. 6*d*.

ANNALS OF MILITARY AND NAVAL SURGERY AND TROPICAL MEDICINE AND HYGIENE,

Embracing the experience of the Medical Officers of Her Majesty's Armies and Fleets in all parts of the World.

Published Annually. Vol. I., price 7*s*.

A CLASSIFIED INDEX
TO
MESSRS. CHURCHILL & SONS' CATALOGUE.

ANATOMY.

PAGE
Anatomical Remembrancer .. 3
Flower on Nerves 11
Hassall's Micros. Anatomy .. 14
Heale's Anatomy of the Lungs 14
Heath's Practical Anatomy .. 15
Holden's Human Osteology .. 15
Do. on Dissections 15
Huxley's Comparative Anatomy 16
Jones' and Sieveking's Pathological Anatomy 17
Maclise's Surgical Anatomy .. 19
St. Bartholomew's Hospital Catalogue 24
Sibson's Medical Anatomy .. 25
Waters' Anatomy of Lung .. 29
Wheeler's Anatomy for Artists 30
Wilson's Anatomy 31

CHEMISTRY.

Abel & Bloxam's Handbook .. 3
Bernays' Notes for Students .. 6
Bowman's Practical Chemistry 7
Do. Medical do. .. 7
Fownes' Manual of Chemistry .. 12
Do. Actonian Prize 12
Do. Qualitative Analysis .. 12
Fresenius' Chemical Analysis .. 12
Galloway's First Step 12
Do. Second Step 12
Do. Analysis 12
Do. Tables 12
Griffiths' Four Seasons 13
Horsley's Chem. Philosophy .. 16
Mulder on the Chemistry of Wine 20
Plattner & Muspratt on Blowpipe 22
Speer's Pathol. Chemistry .. 26
Sutton's Volumetric Analysis . 27

CLIMATE.

Barker on Worthing 4
Bennet on Mentone 6
Dalrymple on Egypt 10
Francis on Change of Climate .. 12
Hall on Torquay 14
Haviland on Climate 14
Lee on Climate 18
Do. Watering Places of England 18
McClelland on Bengal 19
McNicoll on Southport 19
Martin on Tropical Climates .. 20
Moore's Diseases of India .. 20
Scoresby-Jackson's Climatology 24
Shapter on South Devon 25
Siordet on Mentone 25
Taylor on Pau and Pyrenees .. 27

DEFORMITIES, &c.

Adams on Spinal Curvature .. 3
Barwell on Clubfoot 4
Bigg on Deformities 6
Do. on Artificial Limbs 6
Bishop on Deformities 6
Do. Articulate Sounds .. 6
Brodhurst on Spine 7
Do. on Clubfoot 7
Godfrey on Spine 13
Hugman on Hip Joint 16
Tamplin on Spine 27

DISEASES OF WOMEN AND CHILDREN.

PAGE
Ballard on Infants and Mothers 4
Bennet on Uterus 6
Do. on Uterine Pathology .. 6
Bird on Children 7
Bryant's Surg. Diseases of Child. 7
Eyre's Practical Remarks .. 11
Harrison on Children 14
Hood on Scarlet Fever, &c. .. 16
Kiwisch (ed. by Clay) on Ovaries 9
Lee's Ovarian & Uterine Diseases 18
Do. on Diseases of Uterus .. 18
Do. on Speculum 18
Seymour on Ovaria 25
Smith on Leucorrhœa 26
Tilt on Uterine Inflammation .. 28
Do. Uterine Therapeutics .. 28
Do. on Change of Life 28
Underwood on Children 29
Wells on the Ovaries 30
West on Women 30
Do. (Uvedale) on Puerperal Diseases 30

GENERATIVE ORGANS, Diseases of, and SYPHILIS.

Acton on Reproductive Organs 3
Coote on Syphilis 10
Gant on Bladder 13
Hutchinson on Inherited Syphilis 16
Judd on Syphilis 17
Lee on Syphilis 18
Parker on Syphilis 21
Wilson on Syphilis 31

HYGIENE.

Armstrong on Naval Hygiene 4
Beale's Laws of Health 5
Do. Health and Disease .. 5
Bennet on Nutrition 6
Carter on Training 8
Chavasse's Advice to a Mother .. 9
Do. Advice to a Wife .. 9
Dobell's Germs and Vestiges of Disease 11
Do. Diet and Regimen .. 11
Fife & Urquhart on Turkish Bath 11
Granville on Vichy 13
Hartwig on Sea Bathing 14
Do. Physical Education 14
Hufeland's Art of prolonging Life 16
Lee's Baths of Germany 18
Moore's Health in Tropics .. 20
Parkes on Hygiene 21
Parkin on Disease 21
Pickford on Hygiene 21
Robertson on Diet 24
Routh on Infant Feeding 23
Rumsey's State Medicine 24
Tunstall's Bath Waters 28
Wells' Seamen's Medicine Chest 30
Wife's Domain 30
Wilson on Healthy Skin 31
Do. on Mineral Waters .. 31
Do. on Turkish Bath 31

MATERIA MEDICA and PHARMACY.

Bateman's Magnacopia 5
Beasley's Formulary 5
Do. Receipt Book 5
Do. Book of Prescriptions 5
Frazer's Materia Medica 12
Nevins' Analysis of Pharmacop. 20
Pereira's Selecta è Præscriptis 21

MATERIA MEDICA and PHARMACY—*continued.*

PAGE
Pharmacopœia Londinensis .. 22
Prescriber's Pharmacopœia .. 22
Royle's Materia Medica 24
Squire's Hospital Pharmacopœias 26
Do. Companion to the Pharmacopœia 26
Steggall's First Lines for Chemists and Druggists 26
Stowe's Toxicological Chart .. 27
Taylor on Poisons 27
Waring's Therapeutics 29
Wittstein's Pharmacy 31

MEDICINE.

Adams on Rheumatic Gout .. 3
Addison on Cell Therapeutics .. 3
Do. on Healthy and Diseased Structure 3
Aldis's Hospital Practice 3
Anderson on Fever 4
Austin on Paralysis 4
Barclay on Medical Diagnosis .. 4
Barlow's Practice of Medicine 4
Basham on Dropsy 5
Brinton on Stomach 7
Do. on Ulcer of do. 7
Budd on the Liver 8
Do. on Stomach 8
Camplin on Diabetes 8
Chambers on Digestion 8
Do. Lectures 8
Davey's Ganglionic Nervous System 11
Eyre on Stomach 11
French on Cholera 12
Fuller on Rheumatism 12
Gairdner on Gout 12
Gibb on Throat 13
Granville on Sudden Death .. 13
Gully's Simple Treatment .. 13
Habershon on the Abdomen .. 13
Do. on Mercury 13
Hall (Marshall) on Apnœa .. 14
Do. Observations .. 14
Headland—Action of Medicines 14
Hooper's Physician's Vade-Mecum 13
Inman's New Theory 16
Do. Myalgia 16
James on Laryngoscope 17
Maclachlan on Advanced Life .. 19
Marcet on Chronic Alcoholism . 19
Meryon on Paralysis 20
Pavy on Diabetes 21
Peacock on Influenza 21
Peet's Principles and Practice of Medicine 21
Richardson's Asclepiad 23
Roberts on Palsy 23
Robertson on Gout 24
Savory's Compendium 24
Semple on Cough 24
Seymour on Dropsy 25
Shaw's Remembrancer 25
Smee on Debility 25
Thomas' Practice of Physic .. 27
Thudichum on Gall Stones .. 28
Todd's Clinical Lectures 28
Tweedie on Continued Fevers 29
Walker on Diphtheria 29
Wells on Gout 30
What to Observe at the Bedside 19
Williams' Principles 30
Wright on Headaches 31

MICROSCOPE.

PAGE
Beale on Microscope in Medicine 5
Carpenter on Microscope 8
Schacht on do. 24

MISCELLANEOUS.

Acton on Prostitution 3
Barclay's Medical Errors 4
Bascome on Epidemics 4
Bryce on Sebastopol 7
Buckle's Hospital Statistics .. 8
Cooley's Cyclopædia 9
Gordon on China 13
Graves' Physiology and Medicine 13
Guy's Hospital Reports 13
Harrison on Lead in Water .. 14
Hingeston's Topics of the Day .. 15
Lane's Hydropathy 18
Lee on Homœop. and Hydrop. 18
London Hospital Reports 19
Marcet on Food 19
Massy on Recruits 20
Mayne's Medical Vocabulary .. 20
Part's Case Book 21
Redwood's Supplement to Pharmacopœia 23
Ryan on Infanticide 24
Snow on Chloroform 26
Steggall's Medical Manual .. 26
Do. Gregory's Conspectus 26
Do. Celsus 26
Whitehead on Transmission .. 30

NERVOUS DISORDERS AND INDIGESTION.

Birch on Constipation 6
Carter on Hysteria 8
Downing on Neuralgia 11
Hunt on Heartburn 16
Jones (Handfield) on Functional Nervous Disorders 17
Leared on Imperfect Digestion 18
Lobb on Nervous Affections .. 19
Radcliffe on Epilepsy 22
Reynolds on the Brain 23
Do. on Epilepsy 23
Rowe on Nervous Diseases .. 24
Sieveking on Epilepsy 25
Turnbull on Stomach 28

OBSTETRICS.

Barnes on Placenta Prævia .. 4
Hodges on Puerperal Convulsions 15
Lee's Clinical Midwifery 18
Do. Consultations 18
Leishman's Mechanism of Parturition 18
Mackenzie on Phlegmasia Dolens 19
Pretty's Aids during Labour .. 22
Priestley on Gravid Uterus .. 22
Ramsbotham's Obstetrics 23
Do. Midwifery 23
Sinclair & Johnston's Midwifery 25
Smellie's Obstetric Plates 25
Smith's Manual of Obstetrics .. 26
Swayne's Aphorisms 27
Waller's Midwifery 29

OPHTHALMOLOGY.

Cooper on Injuries of Eye .. 9
Do. on Near Sight 9
Dalrymple on Eye 10
Dixon on the Eye 11
Hogg on Ophthalmoscope .. 15
Holthouse on Strabismus 15
Do. on Impaired Vision 15

OPHTHALMOLOGY—*cont^d.*

PAGE
Hulke on the Ophthalmoscope 16
Jacob on Eye-ball 16
Jago on Entoptics 17
Jones' Ophthalmic Medicine .. 17
Do. Defects of Sight 17
Do. Eye and Ear 17
Nunneley on the Organs of Vision 21
Walton on the Eye 29
Wells on Spectacles 30

PHYSIOLOGY.

Carpenter's Human 8
Do. Comparative 8
Do. Manual 8
Heale on Vital Causes 14
O'Reilly on the Nervous System 21
Richardson on Coagulation .. 23
Shea's Animal Physiology 25
Virchow's (ed. by Chance) Cellular Pathology 8

PSYCHOLOGY.

Arlidge on the State of Lunacy 4
Bucknill and Tuke's Psychological Medicine 8
Conolly on Asylums 9
Davey on Nature of Insanity .. 11
Dunn's Physiological Psychology 11
Hood on Criminal Lunatics .. 16
Millingen on Treatment of Insane 20
Noble on Mind 21
Williams (J. H.) Unsoundness of Mind 30

PULMONARY and CHEST DISEASES, &c.

Alison on Pulmonary Consumption 3
Billing on Lungs and Heart .. 6
Bright on the Chest 7
Cotton on Consumption 10
Do. on Stethoscope 10
Davies on Lungs and Heart .. 10
Dobell on the Chest 11
Fenwick on Consumption 11
Fuller on Chest 12
Do. on Heart 12
Jones (Jas.) on Consumption .. 17
Laennec on Auscultation 18
Markham on Heart 20
Richardson on Consumption .. 23
Salter on Asthma 24
Skoda on Auscultation 20
Thompson on Consumption .. 27
Timms on Consumption 28
Turnbull on Consumption .. 28
Waters on Emphysema 29
Weber on Auscultation 29

RENAL and URINARY DISEASES.

Acton on Urinary Organs .. 3
Beale on Urine 5
Bird's Urinary Deposits 6
Coulson on Bladder 10
Hassall on Urine 14
Parkes on Urine 21
Thudichum on Urine 28
Todd on Urinary Organs 28

SCIENCE.

Baxter on Organic Polarity .. 5
Bentley's Manual of Botany .. 6
Bird's Natural Philosophy .. 6

SCIENCE—*continued.*

PAGE
Craig on Electric Tension .. 10
Hardwich's Photography 14
Hinds' Harmonies 15
Howard on the Clouds 16
Jones on Vision 17
Do. on Body, Sense, and Mind 17
Mayne's Lexicon 20
Pratt's Genealogy of Creation .. 22
Do. Eccentric & Centric Force 22
Do. on Orbital Motion 22
Do. Astronomical Investigations 22
Price's Photographic Manipulation 22
Rainey on Shells 23
Reymond's Animal Electricity 23
Taylor's Medical Jurisprudence 27
Unger's Botanical Letters .. 29
Vestiges of Creation 29

SURGERY.

Adams on Reparation of Tendons 3
Do. Subcutaneous Surgery 3
Anderson on the Skin 3
Ashton on Rectum 4
Barwell on Diseases of Joints .. 4
Brodhurst on Anchylosis 7
Bryant on Diseases of Joints .. 7
Callender on Rupture 8
Chapman on Ulcers 9
Do. Varicose Veins 9
Clark's Outlines of Surgery .. 9
Collis on Cancer 9
Cooper (Sir A.) on Testis 10
Do. (S.) Surg. Dictionary 10
Coulson on Lithotomy 10
Curling on Rectum 10
Do. on Testis 10
Druitt's Surgeon's Vade-Mecum 11
Fergusson's Surgery 11
Gant's Principles of Surgery .. 13
Heath's Minor Surgery and Bandaging 15
Higginbottom on Nitrate of Silver 15
Hodgson on Prostate 15
Holt on Stricture 15
James on Hernia 17
Jordan's Clinical Surgery .. 17
Lawrence's Surgery 18
Do. Ruptures 18
Liston's Surgery 18
Logan on Skin Diseases 19
Macleod's Surgical Diagnosis .. 19
Do. Surgery of the Crimea 19
Maclise on Fractures 19
Maunder's Operative Surgery .. 20
Nunneley on Erysipelas 21
Pirrie's Surgery 22
Savage's Female Pelvic Organs 24
Smith (Hy.) on Stricture 25
Do. on Hæmorrhoids 25
Do. on the Surgery of the Rectum 25
Do. (Dr. J.) Dental Anatomy and Surgery 26
Squire on Skin Diseases : .. 26
Steggall's Surgical Manual .. 26
Teale on Amputation 27
Thompson on Stricture 27
Do. on Prostate 27
Do. Lithotomy and Lithotrity 27
Tomes' Dental Surgery 28
Toynbee on Ear 28
Wade on Stricture 29
Watson on the Larynx 29
Webb's Surgeon's Ready Rules 29
Williamson on Military Surgery 30
Do. on Gunshot Injuries 30
Wilson on Skin Diseases 31
Do. Portraits of Skin Diseases 31
Yearsley on Deafness 31
Do. on Throat 31

MR. F. A. ABEL, F.R.S., & MR. C. L. BLOXAM.

HANDBOOK OF CHEMISTRY: THEORETICAL, PRACTICAL, AND TECHNICAL. Second Edition. 8vo. cloth, 15*s.*

MR. ACTON, M.R.C.S.

I.

A PRACTICAL TREATISE ON DISEASES OF THE URINARY AND GENERATIVE ORGANS IN BOTH SEXES. Third Edition. 8vo. cloth, £1. 1*s.* With Plates, £1. 11*s.* 6*d.* The Plates alone, limp cloth, 10*s.* 6*d.*

II.

THE FUNCTIONS AND DISORDERS OF THE REPRODUCTIVE ORGANS IN CHILDHOOD, YOUTH, ADULT AGE, AND ADVANCED LIFE, considered in their Physiological, Social, and Moral Relations. Fourth Edition. 8vo. cloth, 10*s.* 6*d.*

III.

PROSTITUTION: Considered in its Moral, Social, and Sanitary Bearings, with a View to its Amelioration and Regulation. 8vo. cloth, 10*s.* 6*d.*

DR. ADAMS, A.M.

A TREATISE ON RHEUMATIC GOUT; OR, CHRONIC RHEUMATIC ARTHRITIS. 8vo. cloth, with a Quarto Atlas of Plates, 21*s.*

MR. WILLIAM ADAMS, F.R.C.S.

I.

ON THE PATHOLOGY AND TREATMENT OF LATERAL AND OTHER FORMS OF CURVATURE OF THE SPINE. With Plates. 8vo. cloth, 10*s.* 6*d.*

II.

ON THE REPARATIVE PROCESS IN HUMAN TENDONS AFTER SUBCUTANEOUS DIVISION FOR THE CURE OF DEFORMITIES. With Plates. 8vo. cloth, 6*s.*

III.

SKETCH OF THE PRINCIPLES AND PRACTICE OF SUBCUTANEOUS SURGERY. 8vo. cloth, 2*s.* 6*d.*

DR. WILLIAM ADDISON, F.R.S.

I.

CELL THERAPEUTICS. 8vo. cloth, 4*s.*

II.

ON HEALTHY AND DISEASED STRUCTURE, AND THE TRUE PRINCIPLES OF TREATMENT FOR THE CURE OF DISEASE, ESPECIALLY CONSUMPTION AND SCROFULA, founded on MICROSCOPICAL ANALYSIS. 8vo. cloth, 12*s.*

DR. ALDIS.

AN INTRODUCTION TO HOSPITAL PRACTICE IN VARIOUS COMPLAINTS; with Remarks on their Pathology and Treatment. 8vo. cloth, 5*s.* 6*d.*

DR. SOMERVILLE SCOTT ALISON, M.D.EDIN., F.R.C.P.

THE PHYSICAL EXAMINATION OF THE CHEST IN PULMONARY CONSUMPTION, AND ITS INTERCURRENT DISEASES. With Engravings. 8vo. cloth, 12*s.*

THE ANATOMICAL REMEMBRANCER; OR, COMPLETE POCKET ANATOMIST. Fifth Edition, carefully Revised. 32mo. cloth, 3*s.* 6*d.*

DR. McCALL ANDERSON, M.D.

I.

PARASITIC AFFECTIONS OF THE SKIN. With Engravings. 8vo. cloth, 5*s.*

II.

PRACTICAL TREATISE ON ECZEMA. With Engravings. 8vo. cloth, 5*s.*

DR. ANDREW ANDERSON, M.D.

TEN LECTURES INTRODUCTORY TO THE STUDY OF FEVER. Post 8vo. cloth, 5*s*.

DR. ARLIDGE.

ON THE STATE OF LUNACY AND THE LEGAL PROVISION FOR THE INSANE; with Observations on the Construction and Organisation of Asylums. 8vo. cloth, 7*s*.

DR. ALEXANDER ARMSTRONG, R.N.

OBSERVATIONS ON NAVAL HYGIENE AND SCURVY. More particularly as the latter appeared during a Polar Voyage. 8vo. cloth, 5*s*.

MR. T. J. ASHTON.

I.

ON THE DISEASES, INJURIES, AND MALFORMATIONS OF THE RECTUM AND ANUS. Fourth Edition. 8vo. cloth, 8*s*.

II.

PROLAPSUS, FISTULA IN ANO, AND HÆMORRHOIDAL AFFECTIONS; their Pathology and Treatment. Second Edition. Post 8vo. cloth, 2*s*. 6*d*.

MR. THOS. J. AUSTIN, M.R.C.S.ENG.

A PRACTICAL ACCOUNT OF GENERAL PARALYSIS: Its Mental and Physical Symptoms, Statistics, Causes, Seat, and Treatment. 8vo. cloth, 6*s*.

DR. THOMAS BALLARD, M.D.

A NEW AND RATIONAL EXPLANATION OF THE DISEASES PECULIAR TO INFANTS AND MOTHERS; with obvious Suggestions for their Prevention and Cure. Post 8vo. cloth, 4*s*. 6*d*.

DR. BARCLAY.

I.

A MANUAL OF MEDICAL DIAGNOSIS. Second Edition. Foolscap 8vo. cloth, 8*s*. 6*d*.

II.

MEDICAL ERRORS.—Fallacies connected with the Application of the Inductive Method of Reasoning to the Science of Medicine. Post 8vo. cloth, 5*s*.

DR. W. G. BARKER.

ON THE CLIMATE OF WORTHING: its Remedial Influence in Disease, especially of the Lungs. Crown 8vo. cloth, 3*s*.

DR. BARLOW.

A MANUAL OF THE PRACTICE OF MEDICINE. Second Edition. Fcap. 8vo. cloth, 12*s*. 6*d*.

DR. BARNES.

THE PHYSIOLOGY AND TREATMENT OF PLACENTA PRÆVIA; being the Lettsomian Lectures on Midwifery for 1857. Post 8vo. cloth, 6*s*.

MR. BARWELL, F.R.C.S.

I.

A TREATISE ON DISEASES OF THE JOINTS. With Engravings. 8vo. cloth, 12*s*.

II.

ON THE CURE OF CLUBFOOT WITHOUT CUTTING TENDONS, and on certain new Methods of Treating other Deformities. With Engravings. Fcap. 8vo. cloth, 3*s*. 6*d*.

DR. BASCOME.

A HISTORY OF EPIDEMIC PESTILENCES, FROM THE EARLIEST AGES. 8vo. cloth, 8*s*.

DR. BASHAM.

I.

ON DROPSY, CONNECTED WITH DISEASE OF THE KIDNEYS (MORBUS BRIGHTII), and on some other Diseases of those Organs, associated with Albuminous and Purulent Urine. Illustrated by numerous Drawings from the Microscope. Second Edition. 8vo. cloth, *9s.*

II.

THE SIGNIFICANCE OF DROPSY AS A SYMPTOM IN RENAL, CARDIAC, AND PULMONARY DISEASES. The Croonian Lectures for 1864. With Plates. 8vo. cloth, *5s.*

MR. H. F. BAXTER, M.R.C.S.L.

ON ORGANIC POLARITY; showing a Connexion to exist between Organic Forces and Ordinary Polar Forces. Crown 8vo. cloth, *5s.*

MR. BATEMAN.

MAGNACOPIA: A Practical Library of Profitable Knowledge, communicating the general Minutiæ of Chemical and Pharmaceutic Routine, together with the generality of Secret Forms of Preparations. Third Edition. 18mo. *6s.*

MR. LIONEL J. BEALE, M.R.C.S.

I.

THE LAWS OF HEALTH IN THEIR RELATIONS TO MIND AND BODY. A Series of Letters from an Old Practitioner to a Patient. Post 8vo. cloth, *7s. 6d.*

II.

HEALTH AND DISEASE, IN CONNECTION WITH THE GENERAL PRINCIPLES OF HYGIENE. Fcap. 8vo., *2s. 6d.*

DR. BEALE, F.R.S.

I.

URINE, URINARY DEPOSITS, AND CALCULI: and on the Treatment of Urinary Diseases. Numerous Engravings. Second Edition, much Enlarged. Post 8vo. cloth, *8s. 6d.*

II.

THE MICROSCOPE, IN ITS APPLICATION TO PRACTICAL MEDICINE. With a Coloured Plate, and 270 Woodcuts. Second Edition. 8vo. cloth, *14s.*

III.

ILLUSTRATIONS OF THE SALTS OF URINE, URINARY DEPOSITS, and CALCULI. 37 Plates, containing upwards of 170 Figures copied from Nature, with descriptive Letterpress. 8vo. cloth, *9s. 6d.*

MR. BEASLEY.

I.

THE BOOK OF PRESCRIPTIONS; containing 3000 Prescriptions. Collected from the Practice of the most eminent Physicians and Surgeons, English and Foreign. Third Edition. 18mo. cloth, *6s.*

II.

THE DRUGGIST'S GENERAL RECEIPT-BOOK: comprising a copious Veterinary Formulary and Table of Veterinary Materia Medica; Patent and Proprietary Medicines, Druggists' Nostrums, &c.; Perfumery, Skin Cosmetics, Hair Cosmetics, and Teeth Cosmetics; Beverages, Dietetic Articles, and Condiments; Trade Chemicals, Miscellaneous Preparations and Compounds used in the Arts, &c.; with useful Memoranda and Tables. Fifth Edition. 18mo. cloth, *6s.*

III.

THE POCKET FORMULARY AND SYNOPSIS OF THE BRITISH AND FOREIGN PHARMACOPŒIAS; comprising standard and approved Formulæ for the Preparations and Compounds employed in Medical Practice. Seventh Edition, corrected and enlarged. 18mo. cloth, *6s.*

DR. HENRY BENNET.

I.

A PRACTICAL TREATISE ON INFLAMMATION AND OTHER DISEASES OF THE UTERUS. Fourth Edition, revised, with Additions. 8vo. cloth, 16*s.*

II.

A REVIEW OF THE PRESENT STATE OF UTERINE PATHOLOGY. 8vo. cloth, 4*s.*

III.

NUTRITION IN HEALTH AND DISEASE. Post 8vo. cloth, 5*s.*

IV.

MENTONE, THE RIVIERA, CORSICA, AND BIARRITZ, AS WINTER CLIMATES. Second Edition. Post 8vo. cloth, 5*s.*

PROFESSOR BENTLEY, F.L.S.

A MANUAL OF BOTANY. With nearly 1,200 Engravings on Wood. Fcap. 8vo. cloth, 12*s.* 6*d.*

DR. BERNAYS.

NOTES FOR STUDENTS IN CHEMISTRY; being a Syllabus compiled from the Manuals of Miller, Fownes, Berzelius, Gerhardt, Gorup-Besanez, &c. Fourth Edition. Fcap. 8vo. cloth, 3*s.*

MR. HENRY HEATHER BIGG.

I.

THE MECHANICAL APPLIANCES NECESSARY FOR THE TREATMENT OF DEFORMITIES.

PART I.—The Lower Limbs. Post 8vo. cloth, 4*s.*

PART II.—The Spine and Upper Extremities. Post 8vo. cloth, 4*s.* 6*d.*

II.

ARTIFICIAL LIMBS; THEIR CONSTRUCTION AND APPLICATION. With Engravings on Wood. 8vo. cloth, 3*s.*

DR. BILLING, F.R.S.

ON DISEASES OF THE LUNGS AND HEART. 8vo. cloth, 6*s.*

DR. S. B. BIRCH, M.D.

CONSTIPATED BOWELS: the Various Causes and the Rational Means of Cure. Second Edition. Post 8vo. cloth, 3*s.* 6*d.*

DR. GOLDING BIRD, F.R.S.

I.

URINARY DEPOSITS; THEIR DIAGNOSIS, PATHOLOGY, AND THERAPEUTICAL INDICATIONS. With Engravings. Fifth Edition. Edited by E. LLOYD BIRKETT, M.D. Post 8vo. cloth, 10*s.* 6*d.*

II.

ELEMENTS OF NATURAL PHILOSOPHY; being an Experimental Introduction to the Study of the Physical Sciences. With numerous Engravings. Fifth Edition. Edited by CHARLES BROOKE, M.B. Cantab., F.R.S. Fcap. 8vo. cloth, 12*s.* 6*d.*

MR. BISHOP, F.R.S.

I.

ON DEFORMITIES OF THE HUMAN BODY, their Pathology and Treatment. With Engravings on Wood. 8vo. cloth, 10*s.*

II.

ON ARTICULATE SOUNDS, AND ON THE CAUSES AND CURE OF IMPEDIMENTS OF SPEECH. 8vo. cloth, 4*s.*

MR. P. HINCKES BIRD, F.R.C.S.

PRACTICAL TREATISE ON THE DISEASES OF CHILDREN AND INFANTS AT THE BREAST. Translated from the French of M. BOUCHUT, with Notes and Additions. 8vo. cloth. 20*s.*

MR. JOHN E. BOWMAN, & MR. C. L. BLOXAM.

I.

PRACTICAL CHEMISTRY, including Analysis. With numerous Illustrations on Wood. Fourth Edition. Foolscap 8vo. cloth, 6*s.* 6*d.*

II.

MEDICAL CHEMISTRY; with Illustrations on Wood. Fourth Edition, carefully revised. Fcap. 8vo. cloth, 6*s.* 6*d.*

DR. JAMES BRIGHT.

ON DISEASES OF THE HEART, LUNGS, & AIR PASSAGES; with a Review of the several Climates recommended in these Affections. Third Edition. Post 8vo. cloth, 9*s.*

DR. BRINTON, F.R.S.

I.

THE DISEASES OF THE STOMACH, with an Introduction on its Anatomy and Physiology; being Lectures delivered at St. Thomas's Hospital. Second Edition. 8vo. cloth, 10*s.* 6*d.*

II.

THE SYMPTOMS, PATHOLOGY, AND TREATMENT OF ULCER OF THE STOMACH. Post 8vo. cloth, 5*s.*

MR. BERNARD E. BRODHURST, F.R.C.S.

I.

CURVATURES OF THE SPINE: their Causes, Symptoms, Pathology, and Treatment. Second Edition. Roy. 8vo. cloth, with Engravings, 7*s.* 6*d.*

II.

ON THE NATURE AND TREATMENT OF CLUBFOOT AND ANALOGOUS DISTORTIONS involving the TIBIO-TARSAL ARTICULATION. With Engravings on Wood. 8vo. cloth, 4*s.* 6*d.*

III.

PRACTICAL OBSERVATIONS ON THE DISEASES OF THE JOINTS INVOLVING ANCHYLOSIS, and on the TREATMENT for the RESTORATION of MOTION. Third Edition, much enlarged, 8vo. cloth, 4*s.* 6*d.*

MR. THOMAS BRYANT, F.R.C.S.

I.

ON THE DISEASES AND INJURIES OF THE JOINTS. CLINICAL AND PATHOLOGICAL OBSERVATIONS. Post 8vo. cloth, 7*s.* 6*d.*

II.

THE SURGICAL DISEASES OF CHILDREN. The Lettsomian Lectures, delivered March, 1863. Post 8vo. cloth, 5*s.*

DR. BRYCE.

ENGLAND AND FRANCE BEFORE SEBASTOPOL, looked at from a Medical Point of View. 8vo. cloth, 6*s.*

DR. BUCKLE, M.D., L.R.C.P.LOND.

VITAL AND ECONOMICAL STATISTICS OF THE HOSPITALS, INFIRMARIES, &c., OF ENGLAND AND WALES. Royal 8vo. 5*s.*

DR. BUDD, F.R.S.

I.

ON DISEASES OF THE LIVER.

Illustrated with Coloured Plates and Engravings on Wood. Third Edition. 8vo. cloth, 16*s.*

II.

ON THE ORGANIC DISEASES AND FUNCTIONAL DISORDERS OF THE STOMACH. 8vo. cloth, 9*s.*

DR. JOHN CHARLES BUCKNILL, & DR. DANIEL H. TUKE.

A MANUAL OF PSYCHOLOGICAL MEDICINE: containing the History, Nosology, Description, Statistics, Diagnosis, Pathology, and Treatment of Insanity. Second Edition. 8vo. cloth, 15*s.*

MR. CALLENDER, F.R.C.S.

FEMORAL RUPTURE: Anatomy of the Parts concerned. With Plates. 8vo. cloth, 4*s.*

DR. JOHN M. CAMPLIN, F.L.S.

ON DIABETES, AND ITS SUCCESSFUL TREATMENT. Third Edition, by Dr. Glover. Fcap. 8vo. cloth, 3*s.* 6*d.*

MR. ROBERT B. CARTER, M.R.C.S.

I.

ON THE INFLUENCE OF EDUCATION AND TRAINING IN PREVENTING DISEASES OF THE NERVOUS SYSTEM. Fcap. 8vo., 6*s.*

II.

THE PATHOLOGY AND TREATMENT OF HYSTERIA. Post 8vo. cloth, 4*s.* 6*d.*

DR. CARPENTER, F.R.S.

I.

PRINCIPLES OF HUMAN PHYSIOLOGY. With numerous Illustrations on Steel and Wood. Sixth Edition. Edited by Mr. HENRY POWER. 8vo. cloth, 26*s.*

II.

PRINCIPLES OF COMPARATIVE PHYSIOLOGY. Illustrated with 300 Engravings on Wood. Fourth Edition. 8vo. cloth, 24*s.*

III.

A MANUAL OF PHYSIOLOGY. With 252 Illustrations on Steel and Wood. Fourth Edition. Fcap. 8vo. cloth, 12*s.* 6*d.*

IV.

THE MICROSCOPE AND ITS REVELATIONS. With numerous Engravings on Steel and Wood. Third Edition. Fcap. 8vo. cloth, 12*s.* 6*d.*

DR. CHAMBERS.

I.

LECTURES CHIEFLY CLINICAL. Third Edition, much enlarged. 8vo. cloth, 14*s.*

II.

DIGESTION AND ITS DERANGEMENTS. Post 8vo. cloth, 10*s.* 6*d.*

DR. CHANCE, M.B.

VIRCHOW'S CELLULAR PATHOLOGY, AS BASED UPON PHYSIOLOGICAL AND PATHOLOGICAL HISTOLOGY. With 144 Engravings on Wood. 8vo. cloth, 16*s.*

MR. H. T. CHAPMAN, F.R.C.S.

I.

THE TREATMENT OF OBSTINATE ULCERS AND CUTANEOUS ERUPTIONS OF THE LEG WITHOUT CONFINEMENT. Third Edition. Post 8vo. cloth, 3*s.* 6*d.*

II.

VARICOSE VEINS: their Nature, Consequences, and Treatment, Palliative and Curative. Second Edition. Post 8vo. cloth, 3*s.* 6*d.*

MR. PYE HENRY CHAVASSE, F.R.C.S.

I.

ADVICE TO A MOTHER ON THE MANAGEMENT OF HER OFFSPRING. Seventh Edition. Foolscap 8vo., 2*s.* 6*d.*

II.

ADVICE TO A WIFE ON THE MANAGEMENT OF HER OWN HEALTH. With an Introductory Chapter, especially addressed to a Young Wife. Sixth Edition. Fcap. 8vo., 2*s.* 6*d.*

MR. LE GROS CLARK, F.R.C.S.

OUTLINES OF SURGERY; being an Epitome of the Lectures on the Principles and the Practice of Surgery, delivered at St. Thomas's Hospital. Fcap. 8vo. cloth, 5*s.*

MR. JOHN CLAY, M.R.C.S.

KIWISCH ON DISEASES OF THE OVARIES: Translated, by permission, from the last German Edition of his Clinical Lectures on the Special Pathology and Treatment of the Diseases of Women. With Notes, and an Appendix on the Operation of Ovariotomy. Royal 12mo. cloth, 16*s.*

MR. COLLIS, M.B.DUB., F.R.C.S.I.

THE DIAGNOSIS AND TREATMENT OF CANCER AND THE TUMOURS ANALOGOUS TO IT. With coloured Plates. 8vo. cloth, 14*s.*

DR. CONOLLY.

THE CONSTRUCTION AND GOVERNMENT OF LUNATIC ASYLUMS AND HOSPITALS FOR THE INSANE. With Plans. Post 8vo. cloth, 6*s.*

MR. COOLEY.

COMPREHENSIVE SUPPLEMENT TO THE PHARMACOPŒIAS.

THE CYCLOPÆDIA OF PRACTICAL RECEIPTS, PROCESSES, AND COLLATERAL INFORMATION IN THE ARTS, MANUFACTURES, PROFESSIONS, AND TRADES, INCLUDING MEDICINE, PHARMACY, AND DOMESTIC ECONOMY; designed as a General Book of Reference for the Manufacturer, Tradesman, Amateur, and Heads of Families. Fourth and greatly enlarged Edition, 8vo. cloth, 28*s.*

MR. W. WHITE COOPER.

I.

ON WOUNDS AND INJURIES OF THE EYE. Illustrated by 17 Coloured Figures and 41 Woodcuts. 8vo. cloth, 12*s.*

II.

ON NEAR SIGHT, AGED SIGHT, IMPAIRED VISION, AND THE MEANS OF ASSISTING SIGHT. With 31 Illustrations on Wood. Second Edition. Fcap. 8vo. cloth, 7*s.* 6*d.*

SIR ASTLEY COOPER, BART., F.R.S.

ON THE STRUCTURE AND DISEASES OF THE TESTIS. With 24 Plates. Second Edition. Royal 4to., 20*s.*

MR. COOPER.

A DICTIONARY OF PRACTICAL SURGERY AND ENCYCLOPÆDIA OF SURGICAL SCIENCE. New Edition, brought down to the present time. By SAMUEL A. LANE, F.R.C.S., assisted by various eminent Surgeons. Vol. I., 8vo. cloth, £1. 5*s.*

MR. HOLMES COOTE, F.R.C.S.

A REPORT ON SOME IMPORTANT POINTS IN THE TREATMENT OF SYPHILIS. 8vo. cloth, 5*s.*

DR. COTTON.

I.

ON CONSUMPTION: Its Nature, Symptoms, and Treatment. To which Essay was awarded the Fothergillian Gold Medal of the Medical Society of London. Second Edition. 8vo. cloth, 8*s.*

II.

PHTHISIS AND THE STETHOSCOPE; OR, THE PHYSICAL SIGNS OF CONSUMPTION. Third Edition. Foolscap 8vo. cloth, 3*s.*

MR. COULSON.

I.

ON DISEASES OF THE BLADDER AND PROSTATE GLAND. New Edition, revised. *In Preparation.*

II.

ON LITHOTRITY AND LITHOTOMY; with Engravings on Wood. 8vo. cloth, 8*s.*

MR. WILLIAM CRAIG, L.F.P.S., GLASGOW.

ON THE INFLUENCE OF VARIATIONS OF ELECTRIC TENSION AS THE REMOTE CAUSE OF EPIDEMIC AND OTHER DISEASES. 8vo. cloth, 10*s.*

MR. CURLING, F.R.S.

I.

OBSERVATIONS ON DISEASES OF THE RECTUM. Third Edition. 8vo. cloth, 7*s.* 6*d.*

II.

A PRACTICAL TREATISE ON DISEASES OF THE TESTIS, SPERMATIC CORD, AND SCROTUM. Second Edition, with Additions. 8vo. cloth, 14*s.*

DR. DALRYMPLE, M.R.C.P., F.R.C.S.

THE CLIMATE OF EGYPT: METEOROLOGICAL AND MEDICAL OBSERVATIONS, with Practical Hints for Invalid Travellers. Post 8vo. cloth, 4*s.*

MR. JOHN DALRYMPLE, F.R.S., F.R.C.S.

PATHOLOGY OF THE HUMAN EYE. Complete in Nine Fasciculi: imperial 4to., 20*s.* each; half-bound morocco, gilt tops, 9*l.* 15*s.*

DR. HERBERT DAVIES.

ON THE PHYSICAL DIAGNOSIS OF DISEASES OF THE LUNGS AND HEART. Second Edition. Post 8vo. cloth, 8*s.*

DR. DAVEY.

I.

THE GANGLIONIC NERVOUS SYSTEM: its Structure, Functions, and Diseases. 8vo. cloth, 9*s*.

II.

ON THE NATURE AND PROXIMATE CAUSE OF INSANITY. Post 8vo. cloth, 3*s*.

MR. DIXON.

A GUIDE TO THE PRACTICAL STUDY OF DISEASES OF THE EYE. Second Edition. Post 8vo. cloth, 9*s*.

DR. DOBELL.

I.

DEMONSTRATIONS OF DISEASES IN THE CHEST, AND THEIR PHYSICAL DIAGNOSIS. With Coloured Plates. 8vo. cloth, 12*s*. 6*d*.

II.

LECTURES ON THE GERMS AND VESTIGES OF DISEASE, and on the Prevention of the Invasion and Fatality of Disease by Periodical Examinations. 8vo. cloth, 6*s*. 6*d*.

III.

A MANUAL OF DIET AND REGIMEN FOR PHYSICIAN AND PATIENT. Third Edition (for the year 1865). Crown 8vo. cloth, 1*s*. 6*d*.

DR. TOOGOOD DOWNING.

NEURALGIA: its various Forms, Pathology, and Treatment. THE JACKSONIAN PRIZE ESSAY FOR 1850. 8vo. cloth, 10*s*. 6*d*.

DR. DRUITT, F.R.C.S.

THE SURGEON'S VADE-MECUM; with numerous Engravings on Wood. Ninth Edition. Foolscap 8vo. cloth, 12*s*. 6*d*.

MR. DUNN, F.R.C.S.

AN ESSAY ON PHYSIOLOGICAL PSYCHOLOGY. 8vo. cloth, 4*s*.

SIR JAMES EYRE, M.D.

I.

THE STOMACH AND ITS DIFFICULTIES. Fifth Edition. Fcap. 8vo. cloth, 2*s*. 6*d*.

II.

PRACTICAL REMARKS ON SOME EXHAUSTING DISEASES. Second Edition. Post 8vo. cloth, 4*s*. 6*d*.

DR. FENWICK.

ON SCROFULA AND CONSUMPTION. Clergyman's Sore Throat, Catarrh, Croup, Bronchitis, Asthma. Fcap. 8vo., 2*s*. 6*d*.

MR. FERGUSSON, F.R.S.

A SYSTEM OF PRACTICAL SURGERY; with numerous Illustrations on Wood. Fourth Edition. Fcap. 8vo. cloth, 12*s*. 6*d*.

SIR JOHN FIFE, F.R.C.S. AND MR. URQUHART.

MANUAL OF THE TURKISH BATH. Heat a Mode of Cure and a Source of Strength for Men and Animals. With Engravings. Post 8vo. cloth, 5*s*.

MR. FLOWER, F.R.C.S.

DIAGRAMS OF THE NERVES OF THE HUMAN BODY, exhibiting their Origin, Divisions, and Connexions, with their Distribution to the various Regions of the Cutaneous Surface, and to all the Muscles. Folio, containing Six Plates, 14*s*.

MR. FOWNES, PH.D., F.R.S.

I.

A MANUAL OF CHEMISTRY; with 187 Illustrations on Wood. Ninth Edition. Fcap. 8vo. cloth, 12*s.* 6*d.*
Edited by H. BENCE JONES, M.D., F.R.S., and A. W. HOFMANN, PH.D., F.R.S.

II.

CHEMISTRY, AS EXEMPLIFYING THE WISDOM AND BENEFICENCE OF GOD. Second Edition. Fcap. 8vo. cloth, 4*s.* 6*d.*

III.

INTRODUCTION TO QUALITATIVE ANALYSIS. Post 8vo. cloth, 2*s.*

DR. D. J. T. FRANCIS.

CHANGE OF CLIMATE; considered as a Remedy in Dyspeptic, Pulmonary, and other Chronic Affections; with an Account of the most Eligible Places of Residence for Invalids, at different Seasons of the Year. Post 8vo. cloth, 8*s.* 6*d.*

DR. W. FRAZER.

ELEMENTS OF MATERIA MEDICA; containing the Chemistry and Natural History of Drugs—their Effects, Doses, and Adulterations. Second Edition. 8vo. cloth, 10*s.* 6*d.*

MR. J. G. FRENCH, F.R.C.S.

THE NATURE OF CHOLERA INVESTIGATED. Second Edition. 8vo. cloth, 4*s.*

C. REMIGIUS FRESENIUS.

A SYSTEM OF INSTRUCTION IN CHEMICAL ANALYSIS,
Edited by LLOYD BULLOCK, F.C.S.
QUALITATIVE. Sixth Edition, with Coloured Plate illustrating Spectrum Analysis. 8vo. cloth, 10*s.* 6*d.*——QUANTITATIVE. Third Edition. 8vo. cloth, 16*s.*

DR. FULLER.

I.

ON DISEASES OF THE CHEST, including Diseases of the Heart and Great Vessels. With Engravings. 8vo. cloth, 12*s.* 6*d.*

II.

ON DISEASES OF THE HEART AND GREAT VESSELS. 8vo. cloth, 7*s.* 6*d.*

III.

ON RHEUMATISM, RHEUMATIC GOUT, AND SCIATICA: their Pathology, Symptoms, and Treatment. Third Edition. 8vo. cloth, 12*s.* 6*d.*

DR. GAIRDNER.

ON GOUT; its History, its Causes, and its Cure. Fourth Edition. Post 8vo. cloth, 8*s.* 6*d.*

MR. GALLOWAY.

I.

THE FIRST STEP IN CHEMISTRY. Third Edition. Fcap. 8vo. cloth, 5*s.*

II.

THE SECOND STEP IN CHEMISTRY; or, the Student's Guide to the Higher Branches of the Science. With Engravings. 8vo. cloth, 10*s.*

III.

A MANUAL OF QUALITATIVE ANALYSIS. Fourth Edition. Post 8vo. cloth, 6*s.* 6*d.*

IV.

CHEMICAL TABLES. On Five Large Sheets, for School and Lecture Rooms. Second Edition. 4*s.* 6*d.*

MR. F. J. GANT, F.R.C.S.

I.

THE PRINCIPLES OF SURGERY: Clinical, Medical, and Operative. With Engravings. 8vo. cloth, 18*s.*

II.

THE IRRITABLE BLADDER: its Causes and Curative Treatment. Post 8vo. cloth, 4*s.* 6*d.*

DR. GIBB, M.R.C.P.

ON DISEASES OF THE THROAT AND WINDPIPE, as reflected by the Laryngoscope. Second Edition. With 116 Engravings. Post 8vo. cloth, 10*s.* 6*d.*

MRS. GODFREY.

ON THE NATURE, PREVENTION, TREATMENT, AND CURE OF SPINAL CURVATURES and DEFORMITIES of the CHEST and LIMBS, without ARTIFICIAL SUPPORTS or any MECHANICAL APPLIANCES. Third Edition, Revised and Enlarged. 8vo. cloth, 5*s.*

DR. GORDON, M.D., C.B.

CHINA, FROM A MEDICAL POINT OF VIEW, IN 1860 AND 1861; With a Chapter on Nagasaki as a Sanatarium. With Plans. 8vo. cloth, 10*s.* 6*d.*

DR. GRANVILLE, F.R.S.

I.

THE MINERAL SPRINGS OF VICHY: their Efficacy in the Treatment of Gout, Indigestion, Gravel, &c. 8vo. cloth, 3*s.*

II.

ON SUDDEN DEATH. Post 8vo., 2*s.* 6*d.*

DR. GRAVES, M.D., F.R.S.

STUDIES IN PHYSIOLOGY AND MEDICINE. Edited by Dr. Stokes. With Portrait and Memoir. 8vo. cloth, 14*s.*

MR. GRIFFITHS.

CHEMISTRY OF THE FOUR SEASONS—Spring, Summer, Autumn, Winter. Illustrated with Engravings on Wood. Second Edition. Foolscap 8vo. cloth, 7*s.* 6*d.*

DR. GULLY.

THE SIMPLE TREATMENT OF DISEASE; deduced from the Methods of Expectancy and Revulsion. 18mo. cloth, 4*s.*

DR. GUY AND DR. JOHN HARLEY.

HOOPER'S PHYSICIAN'S VADE-MECUM; OR, MANUAL OF THE PRINCIPLES AND PRACTICE OF PHYSIC. Seventh Edition, considerably enlarged, and rewritten. Foolscap 8vo. cloth, 12*s.* 6*d.*

GUY'S HOSPITAL REPORTS. Third Series. Vols. I. to X., 8vo., 7*s.* 6*d.* each.

DR. HABERSHON, F.R.C.P.

I.

PATHOLOGICAL AND PRACTICAL OBSERVATIONS ON DISEASES OF THE ABDOMEN, comprising those of the Stomach and other Parts of the Alimentary Canal, Œsophagus, Stomach, Cæcum, Intestines, and Peritoneum. Second Edition, with Plates. 8vo. cloth, 14*s.*

II.

ON THE INJURIOUS EFFECTS OF MERCURY IN THE TREATMENT OF DISEASE. Post 8vo. cloth, 3*s.* 6*d.*

DR. C. RADCLYFFE HALL.

TORQUAY IN ITS MEDICAL ASPECT AS A RESORT FOR PULMONARY INVALIDS. Post 8vo. cloth, 5*s*.

DR. MARSHALL HALL, F.R.S.

I.

PRONE AND POSTURAL RESPIRATION IN DROWNING AND OTHER FORMS OF APNŒA OR SUSPENDED RESPIRATION. Post 8vo. cloth. 5*s*.

II.

PRACTICAL OBSERVATIONS AND SUGGESTIONS IN MEDICINE. Second Series. Post 8vo. cloth, 8*s*. 6*d*.

MR. HARDWICH.

A MANUAL OF PHOTOGRAPHIC CHEMISTRY. With Engravings. Seventh Edition. Foolscap 8vo. cloth, 7*s*. 6*d*.

DR. J. BOWER HARRISON, M.D., M.R.C.P.

I.

LETTERS TO A YOUNG PRACTITIONER ON THE DISEASES OF CHILDREN. Foolscap 8vo. cloth, 3*s*.

II.

ON THE CONTAMINATION OF WATER BY THE POISON OF LEAD, and its Effects on the Human Body. Foolscap 8vo. cloth, 3*s*. 6*d*.

DR. HARTWIG.

I.

ON SEA BATHING AND SEA AIR. Second Edition. Fcap. 8vo., 2*s*. 6*d*.

II.

ON THE PHYSICAL EDUCATION OF CHILDREN. Fcap. 8vo., 2*s*. 6*d*.

DR. A. H. HASSALL.

I.

THE URINE, IN HEALTH AND DISEASE; being an Explanation of the Composition of the Urine, and of the Pathology and Treatment of Urinary and Renal Disorders. Second Edition. With 79 Engravings (23 Coloured). Post 8vo. cloth, 12*s*. 6*d*.

II.

THE MICROSCOPIC ANATOMY OF THE HUMAN BODY, IN HEALTH AND DISEASE. Illustrated with Several Hundred Drawings in Colour. Two vols. 8vo. cloth, £1. 10*s*.

MR. ALFRED HAVILAND, M.R.C.S.

CLIMATE, WEATHER, AND DISEASE; being a Sketch of the Opinions of the most celebrated Ancient and Modern Writers with regard to the Influence of Climate and Weather in producing Disease. With Four coloured Engravings. 8vo. cloth, 7*s*.

DR. HEADLAND.

ON THE ACTION OF MEDICINES IN THE SYSTEM. Being the Prize Essay to which the Medical Society of London awarded the Fothergillian Gold Medal for 1852. Third Edition. 8vo. cloth, 12*s*. 6*d*.

DR. HEALE.

I.

A TREATISE ON THE PHYSIOLOGICAL ANATOMY OF THE LUNGS. With Engravings. 8vo. cloth, 8*s*.

II.

A TREATISE ON VITAL CAUSES. 8vo. cloth, 9*s*.

MR. CHRISTOPHER HEATH, F.R.C.S.

I.

PRACTICAL ANATOMY: a Manual of Dissections. With numerous Engravings. Fcap. 8vo. cloth, 10*s.* 6*d.*

II.

A MANUAL OF MINOR SURGERY AND BANDAGING, FOR THE USE OF HOUSE-SURGEONS, DRESSERS, AND JUNIOR PRACTITIONERS. With Illustrations. Second Edition. Fcap. 8vo. cloth, 5*s.*

MR. HIGGINBOTTOM, F.R.S., F.R.C.S.E.

ON THE NITRATE OF SILVER: WITH FULL DIRECTIONS FOR ITS APPLICATION IN THE TREATMENT OF INFLAMMATION, WOUNDS, AND ULCERS. Part I., Second Edition, 5*s.*; Part II., 2*s.* 6*d.*

DR. HINDS.

THE HARMONIES OF PHYSICAL SCIENCE IN RELATION TO THE HIGHER SENTIMENTS; with Observations on Medical Studies, and on the Moral and Scientific Relations of Medical Life. Post 8vo. cloth, 4*s.*

MR. J. A. HINGESTON, M.R.C.S.

TOPICS OF THE DAY, MEDICAL, SOCIAL, AND SCIENTIFIC. Crown 8vo. cloth, 7*s.* 6*d.*

DR. HODGES.

THE NATURE, PATHOLOGY, AND TREATMENT OF PUERPERAL CONVULSIONS. Crown 8vo. cloth, 3*s.*

DR. DECIMUS HODGSON.

THE PROSTATE GLAND, AND ITS ENLARGEMENT IN OLD AGE. With 12 Plates. Royal 8vo. cloth, 6*s.*

MR. JABEZ HOGG.

A MANUAL OF OPHTHALMOSCOPIC SURGERY; being a Practical Treatise on the Use of the Ophthalmoscope in Diseases of the Eye. Third Edition. With Coloured Plates. 8vo. cloth, 10*s.* 6*d.*

MR. LUTHER HOLDEN, F.R.C.S.

I.

HUMAN OSTEOLOGY: with Plates, showing the Attachments of the Muscles. Third Edition. 8vo. cloth, 16*s.*

II.

A MANUAL OF THE DISSECTION OF THE HUMAN BODY. With Engravings on Wood. Second Edition. 8vo. cloth, 16*s.*

MR BARNARD HOLT, F.R.C.S.

ON THE IMMEDIATE TREATMENT OF STRICTURE OF THE URETHRA. Second Edition, Enlarged. 8vo. cloth, 3*s.*

MR. C. HOLTHOUSE.

I.

ON SQUINTING, PARALYTIC AFFECTIONS OF THE EYE, and CERTAIN FORMS OF IMPAIRED VISION. Fcap. 8vo. cloth, 4*s.* 6*d.*

II.

LECTURES ON STRABISMUS, delivered at the Westminster Hospital. 8vo. cloth, 4*s.*

DR. W. CHARLES HOOD.

SUGGESTIONS FOR THE FUTURE PROVISION OF CRIMINAL LUNATICS. 8vo. cloth, 5*s.* 6*d.*

DR. P. HOOD.

THE SUCCESSFUL TREATMENT OF SCARLET FEVER; also, OBSERVATIONS ON THE PATHOLOGY AND TREATMENT OF CROWING INSPIRATIONS OF INFANTS. Post 8vo. cloth, 5*s.*

MR. JOHN HORSLEY.

A CATECHISM OF CHEMICAL PHILOSOPHY; being a Familiar Exposition of the Principles of Chemistry and Physics. With Engravings on Wood. Designed for the Use of Schools and Private Teachers. Post 8vo. cloth, 6*s.* 6*d.*

MR. LUKE HOWARD, F.R.S.

ESSAY ON THE MODIFICATIONS OF CLOUDS. Third Edition, by W. D. and E. HOWARD. With 6 Lithographic Plates, from Pictures by Kenyon. 4to. cloth, 10*s.* 6*d.*

DR. HUFELAND.

THE ART OF PROLONGING LIFE. Second Edition. Edited by ERASMUS WILSON, F.R.S. Foolscap 8vo., 2*s.* 6*d.*

MR. W. CURTIS HUGMAN, F.R.C.S.

ON HIP-JOINT DISEASE; with reference especially to Treatment by Mechanical Means for the Relief of Contraction and Deformity of the Affected Limb. 8vo. cloth, 3*s.* 6*d.*

MR. HULKE, F.R.C.S.

A PRACTICAL TREATISE ON THE USE OF THE OPHTHALMOSCOPE. Being the Jacksonian Prize Essay for 1859. Royal 8vo. cloth, 8*s.*

DR. HENRY HUNT.

ON HEARTBURN AND INDIGESTION. 8vo. cloth, 5*s.*

PROFESSOR HUXLEY, F.R.S.

LECTURES ON THE ELEMENTS OF COMPARATIVE ANATOMY.—ON CLASSIFICATON AND THE SKULL. With 111 Illustrations. 8vo. cloth, 10*s.* 6*d.*

MR. JONATHAN HUTCHINSON, F.R.C.S.

A CLINICAL MEMOIR ON CERTAIN DISEASES OF THE EYE AND EAR, CONSEQUENT ON INHERITED SYPHILIS; with an appended Chapter of Commentaries on the Transmission of Syphilis from Parent to Offspring, and its more remote Consequences. With Plates and Woodcuts, 8vo. cloth, 9*s.*

DR. INMAN, M.R.C.P.

I.

ON MYALGIA: ITS NATURE, CAUSES, AND TREATMENT; being a Treatise on Painful and other Affections of the Muscular System. Second Edition. 8vo. cloth, 9*s.*

II.

FOUNDATION FOR A NEW THEORY AND PRACTICE OF MEDICINE. Second Edition. Crown 8vo. cloth, 10*s.*

DR. ARTHUR JACOB, F.R.C.S.

A TREATISE ON THE INFLAMMATIONS OF THE EYE-BALL. Foolscap 8vo. cloth, 5*s.*

DR. JAGO, M.D.OXON., A.B.CANTAB.

ENTOPTICS, WITH ITS USES IN PHYSIOLOGY AND MEDICINE. With 54 Engravings. Crown 8vo. cloth, 5*s.*

MR. J. H. JAMES, F.R.C.S.

PRACTICAL OBSERVATIONS ON THE OPERATIONS FOR STRANGULATED HERNIA. 8vo. cloth, 5*s.*

DR. PROSSER JAMES, M.D.

SORE-THROAT: ITS NATURE, VARIETIES, AND TREATMENT; including the Use of the LARYNGOSCOPE as an Aid to Diagnosis. Post 8vo. cloth, 4*s.* 6*d.*

DR. HANDFIELD JONES, M.B., F.R.C.P.

CLINICAL OBSERVATIONS ON FUNCTIONAL NERVOUS DISORDERS. Post 8vo. cloth, 10*s.* 6*d.*

DR. HANDFIELD JONES, F.R.S., & DR. EDWARD H. SIEVEKING.

A MANUAL OF PATHOLOGICAL ANATOMY. Illustrated with numerous Engravings on Wood. Foolscap 8vo. cloth, 12*s.* 6*d.*

DR. JAMES JONES, M.D., M.R.C.P.

ON THE USE OF PERCHLORIDE OF IRON AND OTHER CHALYBEATE SALTS IN THE TREATMENT OF CONSUMPTION. Crown 8vo. cloth, 3*s.* 6*d.*

MR. WHARTON JONES, F.R.S.

I.

A MANUAL OF THE PRINCIPLES AND PRACTICE OF OPHTHALMIC MEDICINE AND SURGERY; illustrated with Engravings, plain and coloured. Second Edition. Foolscap 8vo. cloth, 12*s.* 6*d.*

II.

THE WISDOM AND BENEFICENCE OF THE ALMIGHTY, AS DISPLAYED IN THE SENSE OF VISION; being the Actonian Prize Essay for 1851. With Illustrations on Steel and Wood. Foolscap 8vo. cloth, 4*s.* 6*d.*

III.

DEFECTS OF SIGHT: their Nature, Causes, Prevention, and General Management. Fcap. 8vo. 2*s.* 6*d.*

IV.

A CATECHISM OF THE MEDICINE AND SURGERY OF THE EYE AND EAR. For the Clinical Use of Hospital Students. Fcap. 8vo. 2*s.* 6*d.*

V.

A CATECHISM OF THE PHYSIOLOGY AND PHILOSOPHY OF BODY, SENSE, AND MIND. For Use in Schools and Colleges. Fcap. 8vo., 2*s.* 6*d.*

MR. FURNEAUX JORDAN, M.R.C.S.

AN INTRODUCTION TO CLINICAL SURGERY; WITH A Method of Investigating and Reporting Surgical Cases. Fcap. 8vo. cloth, 5*s.*

MR. JUDD.

A PRACTICAL TREATISE ON URETHRITIS AND SYPHILIS: including Observations on the Power of the Menstruous Fluid, and of the Discharge from Leucorrhœa and Sores to produce Urethritis: with a variety of Examples, Experiments, Remedies, and Cures. 8vo. cloth, £1. 5*s.*

DR. LAENNEC.

A MANUAL OF AUSCULTATION AND PERCUSSION. Translated and Edited by J. B. SHARPE, M.R.C.S. 3*s*.

DR. LANE, M.A.

HYDROPATHY; OR, HYGIENIC MEDICINE. An Explanatory Essay. Second Edition. Post 8vo. cloth, 5*s*.

MR. LAWRENCE, F.R.S.

I.

LECTURES ON SURGERY. 8vo. cloth, 16*s*.

II.

A TREATISE ON RUPTURES. The Fifth Edition, considerably enlarged. 8vo. cloth, 16*s*.

DR. LEARED, M.R.C.P.

IMPERFECT DIGESTION: ITS CAUSES AND TREATMENT. Third Edition. Foolscap 8vo. cloth, 4*s*.

DR. EDWIN LEE.

I.

THE EFFECT OF CLIMATE ON TUBERCULOUS DISEASE, with Notices of the chief Foreign Places of Winter Resort. Small 8vo. cloth, 4*s*. 6*d*.

II.

THE WATERING PLACES OF ENGLAND, CONSIDERED with Reference to their Medical Topography. Fourth Edition. Fcap. 8vo. cloth, 7*s*. 6*d*.

III.

THE BATHS OF GERMANY. Fourth Edition. Post 8vo. cloth, 7*s*.

IV.

HOMŒOPATHY AND HYDROPATHY IMPARTIALLY APPRECIATED. With Notes illustrative of the Influence of the Mind over the Body. Fourth Edition. Post 8vo. cloth, 3*s*. 6*d*.

MR. HENRY LEE, F.R.C.S.

ON SYPHILIS. Second Edition. With Coloured Plates. 8vo. cloth, 10*s*.

DR. ROBERT LEE, F.R.S.

I.

CONSULTATIONS IN MIDWIFERY. Foolscap 8vo. cloth, 4*s*. 6*d*.

II.

A TREATISE ON THE SPECULUM; with Three Hundred Cases. 8vo. cloth, 4*s*. 6*d*.

III.

CLINICAL REPORTS OF OVARIAN AND UTERINE DISEASES, with Commentaries. Foolscap 8vo. cloth, 6*s*. 6*d*.

IV.

CLINICAL MIDWIFERY: comprising the Histories of 545 Cases of Difficult, Preternatural, and Complicated Labour, with Commentaries. Second Edition. Foolscap 8vo. cloth, 5*s*.

V.

PRACTICAL OBSERVATIONS ON DISEASES OF THE UTERUS. With coloured Plates. Two Parts. Imperial 4to., 7*s*. 6*d*. each Part.

DR. LEISHMAN, M.D., F.F.P.S.

THE MECHANISM OF PARTURITION: An Essay, Historical and Critical. With Engravings. 8vo. cloth, 5*s*.

MR. LISTON, F.R.S.

PRACTICAL SURGERY. Fourth Edition. 8vo. cloth, 22*s*.

MR. H. W. LOBB, L.S.A., M.R.C.S.E.

ON SOME OF THE MORE OBSCURE FORMS OF NERVOUS AFFECTIONS, THEIR PATHOLOGY AND TREATMENT. Re-issue, with the Chapter on Galvanism entirely Re-written. With Engravings. 8vo. cloth, 8*s.*

DR. LOGAN, M.D., M.R.C.P.LOND.

ON OBSTINATE DISEASES OF THE SKIN. Foolscap 8vo. cloth, 2*s.* 6*d.*

LONDON HOSPITAL.

CLINICAL LECTURES AND REPORTS BY THE MEDICAL AND SURGICAL STAFF. With Illustrations. Vol. I. 8vo. cloth, 7*s.* 6*d.*

LONDON MEDICAL SOCIETY OF OBSERVATION.

WHAT TO OBSERVE AT THE BED-SIDE, AND AFTER DEATH. Published by Authority. Second Edition. Foolscap 8vo. cloth, 4*s.* 6*d.*

DR. MACKENZIE, M.D., M.R.C.P.

THE PATHOLOGY AND TREATMENT OF PHLEGMASIA DOLENS, as deduced from Clinical and Physiological Researches. Lettsomian Lectures on Midwifery. 8vo. cloth, 6*s.*

MR. M'CLELLAND, F.L.S., F.G.S.

THE MEDICAL TOPOGRAPHY, OR CLIMATE AND SOILS, OF BENGAL AND THE N. W. PROVINCES. Post 8vo. cloth, 4*s.* 6*d.*

DR. MACLACHLAN, M.D., F.R.C.P.L.

THE DISEASES AND INFIRMITIES OF ADVANCED LIFE. 8vo. cloth, 16*s.*

DR. GEORGE H. B. MACLEOD, F.R.C.S.E.

I.

OUTLINES OF SURGICAL DIAGNOSIS. 8vo. cloth, 12*s.* 6*d.*

II.

NOTES ON THE SURGERY OF THE CRIMEAN WAR; with REMARKS on GUN-SHOT WOUNDS. 8vo. cloth, 10*s.* 6*d.*

MR. JOSEPH MACLISE, F.R.C.S.

I.

SURGICAL ANATOMY. A Series of Dissections, illustrating the Principal Regions of the Human Body.
The Second Edition, imperial folio, cloth, £3. 12*s.*; half-morocco, £4. 4*s.*

II.

ON DISLOCATIONS AND FRACTURES. This Work is Uniform with the Author's "Surgical Anatomy;" each Fasciculus contains Four beautifully executed Lithographic Drawings. Imperial folio, cloth, £2. 10*s.*; half-morocco, £2. 17*s.*

DR. McNICOLL, M.R.C.P.

A HAND-BOOK FOR SOUTHPORT, MEDICAL & GENERAL; with Copious Notices of the Natural History of the District. Second Edition. Post 8vo. cloth, 3*s.* 6*d.*

DR. MARCET, F.R.S.

I.

ON THE COMPOSITION OF FOOD, AND HOW IT IS ADULTERATED; with Practical Directions for its Analysis. 8vo. cloth, 6*s.* 6*d.*

II.

ON CHRONIC ALCOHOLIC INTOXICATION; with an INQUIRY INTO THE INFLUENCE OF THE ABUSE OF ALCOHOL AS A PREDISPOSING CAUSE OF DISEASE. Second Edition, much enlarged. Foolscap 8vo. cloth, 4*s.* 6*d.*

DR. MARKHAM.

I.

DISEASES OF THE HEART: THEIR PATHOLOGY, DIAGNOSIS, AND TREATMENT. Second Edition. Post 8vo. cloth, 6*s*.

II.

SKODA ON AUSCULTATION AND PERCUSSION. Post 8vo. cloth, 6*s*.

SIR RANALD MARTIN, K.C.B., F.R.S.

INFLUENCE OF TROPICAL CLIMATES IN PRODUCING THE ACUTE ENDEMIC DISEASES OF EUROPEANS; including Practical Observations on their Chronic Sequelæ under the Influences of the Climate of Europe. Second Edition, much enlarged. 8vo. cloth, 20*s*.

DR. MASSY.

ON THE EXAMINATION OF RECRUITS; intended for the Use of Young Medical Officers on Entering the Army. 8vo. cloth, 5*s*.

MR. C. F. MAUNDER, F.R.C.S.

OPERATIVE SURGERY. With 158 Engravings. Post 8vo. 6*s*.

DR. MAYNE.

I.

AN EXPOSITORY LEXICON OF HE TERMS, ANCIENT AND MODERN, IN MEDICAL AND GENERAL SCIENCE, including a complete MEDICAL AND MEDICO-LEGAL VOCABULARY. Complete in 10 Parts, price 5*s*. each. The entire work, cloth, £2. 10*s*.

II.

A MEDICAL VOCABULARY; or, an Explanation of all Names, Synonymes, Terms, and Phrases used in Medicine and the relative branches of Medical Science, intended specially as a Book of Reference for the Young Student. Second Edition. Fcap. 8vo. cloth, 8*s*. 6*d*.

DR. MERYON, M.D., F.R.C.P.

PATHOLOGICAL AND PRACTICAL RESEARCHES ON THE VARIOUS FORMS OF PARALYSIS. 8vo. cloth, 6*s*.

DR. MILLINGEN.

ON THE TREATMENT AND MANAGEMENT OF THE INSANE; with Considerations on Public and Private Lunatic Asylums. 18mo. cloth, 4*s*. 6*d*.

DR. W. J. MOORE, M.D.

I.

HEALTH IN THE TROPICS; or, Sanitary Art applied to Europeans in India. 8vo. cloth, 9*s*.

II.

A MANUAL OF THE DISEASES OF INDIA. Fcap. 8vo. cloth, 5*s*.

PROFESSOR MULDER, UTRECHT.

THE CHEMISTRY OF WINE. Edited by H. Bence Jones, M.D., F.R.S. Fcap. 8vo. cloth, 6*s*.

DR. BIRKBECK NEVINS.

THE PRESCRIBER'S ANALYSIS OF THE BRITISH PHARMACOPEIA. Second Edition, enlarged to 264 pp. 32mo. cloth, 3*s*. 6*d*.

DR. NOBLE.

THE HUMAN MIND IN ITS RELATIONS WITH THE BRAIN AND NERVOUS SYSTEM. Post 8vo. cloth, 4*s.* 6*d.*

MR. NUNNELEY, F.R.C.S.E.

I.

ON THE ORGANS OF VISION: THEIR ANATOMY AND PHYSIOLOGY. With Plates, 8vo. cloth, 15*s.*

II.

A TREATISE ON THE NATURE, CAUSES, AND TREATMENT OF ERYSIPELAS. 8vo. cloth, 10*s.* 6*d.*

DR. O'REILLY.

THE PLACENTA, THE ORGANIC NERVOUS SYSTEM, THE BLOOD, THE OXYGEN, AND THE ANIMAL NERVOUS SYSTEM, PHYSIOLOGICALLY EXAMINED. With Engravings. 8vo. cloth, 5*s.*

MR. LANGSTON PARKER.

THE MODERN TREATMENT OF SYPHILITIC DISEASES, both Primary and Secondary; comprising the Treatment of Constitutional and Confirmed Syphilis, by a safe and successful Method. Fourth Edition, 8vo. cloth, 10*s.*

DR. PARKES, F.R.C.P.

I.

A MANUAL OF PRACTICAL HYGIENE; intended especially for the Medical Officers of the Army. With Plates and Woodcuts. 8vo. cloth, 16*s.*

II.

THE URINE: ITS COMPOSITION IN HEALTH AND DISEASE, AND UNDER THE ACTION OF REMEDIES. 8vo. cloth, 12*s.*

DR. PARKIN, M.D., F.R.C.S.

THE CAUSATION AND PREVENTION OF DISEASE; with the Laws regulating the Extrication of Malaria from the Surface, and its Diffusion in the surrounding Air. 8vo. cloth, 5*s.*

MR. JAMES PART, F.R.C.S.

THE MEDICAL AND SURGICAL POCKET CASE BOOK, for the Registration of important Cases in Private Practice, and to assist the Student of Hospital Practice. Second Edition. 2*s.* 6*d.*

DR. PAVY, M.D., F.R.S., F.R.C.P.

DIABETES: RESEARCHES ON ITS NATURE AND TREATMENT. 8vo. cloth, 8*s.* 6*d.*

DR. THOMAS B. PEACOCK, M.D.

ON THE INFLUENZA, OR EPIDEMIC CATARRHAL FEVER OF 1847-8. 8vo. cloth, 5*s.* 6*d.*

DR. PEET, M.D., F.R.C.P.

THE PRINCIPLES AND PRACTICE OF MEDICINE; Designed chiefly for Students of Indian Medical Colleges. 8vo. cloth, 16*s.*

DR. PEREIRA, F.R.S.

SELECTA E PRÆSCRIPTIS. Fourteenth Edition. 24mo. cloth, 5*s.*

DR. PICKFORD.

HYGIENE; or, Health as Depending upon the Conditions of the Atmosphere, Food and Drinks, Motion and Rest, Sleep and Wakefulness, Secretions, Excretions, and Retentions, Mental Emotions, Clothing, Bathing, &c. Vol. I. 8vo. cloth, 9*s.*

MR. PIRRIE, F.R.S.E.

THE PRINCIPLES AND PRACTICE OF SURGERY. With numerous Engravings on Wood. Second Edition. 8vo. cloth, 24*s.*

PHARMACOPŒIA COLLEGII REGALIS MEDICORUM LONDINENSIS. 8vo. cloth, 9*s.*; or 24mo. 5*s.*

IMPRIMATUR.

Hic liber, cui titulus, PHARMACOPŒIA COLLEGII REGALIS MEDICORUM LONDINENSIS. Datum ex Ædibus Collegii in comitiis censoriis, Novembris Mensis 14^to^ 1850.

JOHANNES AYRTON PARIS. *Præses.*

PROFESSORS PLATTNER & MUSPRATT.

THE USE OF THE BLOWPIPE IN THE EXAMINATION OF MINERALS, ORES, AND OTHER METALLIC COMBINATIONS. Illustrated by numerous Engravings on Wood. Third Edition. 8vo. cloth, 10*s.* 6*d.*

DR. HENRY F. A PRATT, M.D., M.R.C.P.

I.

THE GENEALOGY OF CREATION, newly Translated from the Unpointed Hebrew Text of the Book of Genesis, showing the General Scientific Accuracy of the Cosmogony of Moses and the Philosophy of Creation. 8vo. cloth, 14*s.*

II.

ON ECCENTRIC AND CENTRIC FORCE: A New Theory of Projection. With Engravings. 8vo. cloth, 10*s.*

III.

ON ORBITAL MOTION: The Outlines of a System of Physical Astronomy. With Diagrams. 8vo. cloth, 7*s.* 6*d.*

IV.

ASTRONOMICAL INVESTIGATIONS. The Cosmical Relations of the Revolution of the Lunar Apsides. Oceanic Tides. With Engravings. 8vo. cloth, 5*s.*

THE PRESCRIBER'S PHARMACOPŒIA; containing all the Medicines in the British Pharmacopœia, arranged in Classes according to their Action, with their Composition and Doses. By a Practising Physician. Fifth Edition. 32mo. cloth, 2*s.* 6*d.*; roan tuck (for the pocket), 3*s.* 6*d.*

DR. JOHN ROWLISON PRETTY.

AIDS DURING LABOUR, including the Administration of Chloroform, the Management of Placenta and Post-partum Hæmorrhage. Fcap. 8vo. cloth, 4*s.* 6*d.*

MR. LAKE PRICE.

PHOTOGRAPHIC MANIPULATION: Treating of the Practice of the Art, and its various appliances to Nature. With Fifty Engravings on Wood. Post 8vo. cloth, 6*s.* 6*d.*

DR. PRIESTLEY.

LECTURES ON THE DEVELOPMENT OF THE GRAVID UTERUS. 8vo. cloth, 5*s.* 6*d.*

DR. RADCLIFFE, F.R.C.P.L.

LECTURES ON EPILEPSY, PAIN, PARALYSIS, AND CERTAIN OTHER DISORDERS OF THE NERVOUS SYSTEM, delivered at the Royal College of Physicians in London. Post 8vo. cloth, 7*s.* 6*d.*

MR. RAINEY.

ON THE MODE OF FORMATION OF SHELLS OF ANIMALS, OF BONE, AND OF SEVERAL OTHER STRUCTURES, by a Process of Molecular Coalescence, Demonstrable in certain Artificially-formed Products. Fcap. 8vo. cloth, 4*s.* 6*d.*

DR. F. H. RAMSBOTHAM.

THE PRINCIPLES AND PRACTICE OF OBSTETRIC MEDICINE AND SURGERY. Illustrated with One Hundred and Twenty Plates on Steel and Wood; forming one thick handsome volume. Fourth Edition. 8vo. cloth, 22*s.*

DR. RAMSBOTHAM.

PRACTICAL OBSERVATIONS ON MIDWIFERY, with a Selection of Cases. Second Edition. 8vo. cloth, 12*s.*

PROFESSOR REDWOOD, PH. D.

A SUPPLEMENT TO THE PHARMACOPŒIA; A concise but comprehensive Dispensatory, and Manual of Facts and Formulæ, for the use of Practitioners in Medicine and Pharmacy. Third Edition. 8vo. cloth, 22*s.*

DR. DU BOIS REYMOND.

ANIMAL ELECTRICITY; Edited by H. Bence Jones, M.D., F.R.S. With Fifty Engravings on Wood. Foolscap 8vo. cloth, 6*s.*

DR. REYNOLDS, M.D.LOND.

I.

EPILEPSY: ITS SYMPTOMS, TREATMENT, AND RELATION TO OTHER CHRONIC CONVULSIVE DISEASES. 8vo. cloth, 10*s.*

II.

THE DIAGNOSIS OF DISEASES OF THE BRAIN, SPINAL CORD, AND THEIR APPENDAGES. 8vo. cloth, 8*s.*

DR. B. W. RICHARDSON.

I.

ON THE CAUSE OF THE COAGULATION OF THE BLOOD. Being the Astley Cooper Prize Essay for 1856. With a Practical Appendix. 8vo. cloth, 16*s.*

II.

THE HYGIENIC TREATMENT OF PULMONARY CONSUMPTION. 8vo. cloth, 5*s.* 6*d.*

III.

THE ASCLEPIAD. Vol. I., Clinical Essays. 8vo. cloth, 6*s.* 6*d.*

MR. WILLIAM ROBERTS.

AN ESSAY ON WASTING PALSY; being a Systematic Treatise on the Disease hitherto described as ATROPHIE MUSCULAIRE PROGRESSIVE. With Four Plates. 8vo. cloth, 7*s.* 6*d.*

DR. ROUTH.

INFANT FEEDING, AND ITS INFLUENCE ON LIFE; Or, the Causes and Prevention of Infant Mortality. Second Edition. Fcap. 8vo. cloth, 6*s.*

DR. W. H. ROBERTSON.

I.

THE NATURE AND TREATMENT OF GOUT.

8vo. cloth, 10*s.* 6*d.*

II.

A TREATISE ON DIET AND REGIMEN.

Fourth Edition. 2 vols. post 8vo. cloth, 12*s.*

DR. ROWE.

NERVOUS DISEASES, LIVER AND STOMACH COMPLAINTS, LOW SPIRITS, INDIGESTION, GOUT, ASTHMA, AND DISORDERS PRODUCED BY TROPICAL CLIMATES.

With Cases. Sixteenth Edition. Fcap. 8vo. 2*s.* 6*d.*

DR. ROYLE, F.R.S., AND DR. HEADLAND, M.D.

A MANUAL OF MATERIA MEDICA AND THERAPEUTICS.

With numerous Engravings on Wood. Fourth Edition. Fcap. 8vo. cloth, 12*s.* 6*d.*

MR. RUMSEY, F.R.C.S.

ESSAYS ON STATE MEDICINE.

8vo. cloth, 10*s.* 6*d.*

DR. RYAN, M.D.

INFANTICIDE: ITS LAW, PREVALENCE, PREVENTION, AND HISTORY.

8vo. cloth, 5*s.*

ST. BARTHOLOMEW'S HOSPITAL.

A DESCRIPTIVE CATALOGUE OF THE ANATOMICAL MUSEUM.

Vol. I. (1846), Vol. II. (1851), Vol. III. (1862), 8vo. cloth, 5*s.* each.

DR. SALTER, F.R.S.

ON ASTHMA: its Pathology, Causes, Consequences, and Treatment.

8vo. cloth, 10*s.*

DR. SAVAGE, M.D.LOND., F.R.C.S.

THE SURGERY OF THE FEMALE PELVIC ORGANS,

in a Series of Plates taken from Nature, with Physiological and Pathological References. Royal 4to. cloth, 20*s.*

*** These Plates give 40 Illustrations taken from original Dissections, and are drawn and coloured in the highest degree of art.

MR. SAVORY.

A COMPENDIUM OF DOMESTIC MEDICINE, AND COMPANION TO THE MEDICINE CHEST;

intended as a Source of Easy Reference for Clergymen, and for Families residing at a Distance from Professional Assistance. Seventh Edition. 12mo. cloth, 5*s.*

DR. SCHACHT.

THE MICROSCOPE, AND ITS APPLICATION TO VEGETABLE ANATOMY AND PHYSIOLOGY.

Edited by FREDERICK CURREY, M.A. Fcap. 8vo. cloth, 6*s.*

DR. SCORESBY-JACKSON, M.D., F.R.S.E.

MEDICAL CLIMATOLOGY; or, a Topographical and Meteorological Description of the Localities resorted to in Winter and Summer by Invalids of various classes both at Home and Abroad.

With an Isothermal Chart. Post 8vo. cloth, 12*s.*

DR. SEMPLE.

ON COUGH: its Causes, Varieties, and Treatment.

With some practical Remarks on the Use of the Stethoscope as an aid to Diagnosis. Post 8vo. cloth, 4*s.* 6*d.*

DR. SEYMOUR.

I.

ILLUSTRATIONS OF SOME OF THE PRINCIPAL DISEASES OF THE OVARIA: their Symptoms and Treatment; to which are prefixed Observations on the Structure and Functions of those parts in the Human Being and in Animals. With 14 folio plates, 12*s*.

II.

THE NATURE AND TREATMENT OF DROPSY; considered especially in reference to the Diseases of the Internal Organs of the Body, which most commonly produce it. 8vo. 5*s*.

DR. SHAPTER, M.D., F.R.C.P.

THE CLIMATE OF THE SOUTH OF DEVON, AND ITS INFLUENCE UPON HEALTH. Second Edition, with Maps. 8vo. cloth, 10*s*. 6*d*.

MR. SHAW, M.R.C.S.

THE MEDICAL REMEMBRANCER; OR, BOOK OF EMERGENCIES: in which are concisely pointed out the Immediate Remedies to be adopted in the First Moments of Danger from Drowning, Poisoning, Apoplexy, Burns, and other Accidents; with the Tests for the Principal Poisons, and other useful Information. Fourth Edition. Edited, with Additions, by JONATHAN HUTCHINSON, F.R.C.S. 32mo. cloth, 2*s*. 6*d*.

DR. SHEA, M.D., B.A.

A MANUAL OF ANIMAL PHYSIOLOGY. With an Appendix of Questions for the B.A. London and other Examinations. With Engravings. Foolscap 8vo. cloth, 5*s*. 6*d*.

DR. SIBSON, F.R.S.

MEDICAL ANATOMY. With coloured Plates. Imperial folio. Fasciculi I. to VI. 5*s*. each.

DR. E. H. SIEVEKING.

ON EPILEPSY AND EPILEPTIFORM SEIZURES: their Causes, Pathology, and Treatment. Second Edition. Post 8vo. cloth, 10*s*. 6*d*.

MR. SINCLAIR AND DR. JOHNSTON.

PRACTICAL MIDWIFERY: Comprising an Account of 13,748 Deliveries, which occurred in the Dublin Lying-in Hospital, during a period of Seven Years. 8vo. cloth, 15*s*.

DR. SIORDET, M.B.LOND., M.R.C.P.

MENTONE IN ITS MEDICAL ASPECT. Foolscap 8vo. cloth, 2*s*. 6*d*.

MR. ALFRED SMEE, F.R.S.

GENERAL DEBILITY AND DEFECTIVE NUTRITION; their Causes, Consequences, and Treatment. Second Edition. Fcap. 8vo. cloth, 3*s*. 6*d*.

DR. SMELLIE.

OBSTETRIC PLATES: being a Selection from the more Important and Practical Illustrations contained in the Original Work. With Anatomical and Practical Directions. 8vo. cloth, 5*s*.

MR. HENRY SMITH, F.R.C.S.

I.

ON STRICTURE OF THE URETHRA. 8vo. cloth, 7*s*. 6*d*.

II.

HÆMORRHOIDS AND PROLAPSUS OF THE RECTUM: Their Pathology and Treatment, with especial reference to the use of Nitric Acid. Third Edition. Fcap. 8vo. cloth, 3*s*.

III.

THE SURGERY OF THE RECTUM. Lettsomian Lectures. Fcap. 8vo. 2*s*. 6*d*.

DR. J. SMITH, M.D., F.R.C.S.EDIN.

HANDBOOK OF DENTAL ANATOMY AND SURGERY, FOR THE USE OF STUDENTS AND PRACTITIONERS.

Fcap. 3vo. cloth, 3*s.* 6*d.*

DR. W. TYLER SMITH.

I.

A MANUAL OF OBSTETRICS, THEORETICAL AND PRACTICAL.

Illustrated with 136 Engravings. Fcap. 8vo. cloth, 12*s.* 6*d.*

II.

THE PATHOLOGY AND TREATMENT OF LEUCORRHŒA.

With Engravings on Wood. 8vo. cloth, 7*s.*

DR. SNOW.

ON CHLOROFORM AND OTHER ANÆSTHETICS: THEIR ACTION AND ADMINISTRATION.

Edited, with a Memoir of the Author, by Benjamin W. Richardson, M.D. 8vo. cloth, 10*s.* 6*d.*

DR. STANHOPE TEMPLEMAN SPEER.

PATHOLOGICAL CHEMISTRY, IN ITS APPLICATION TO THE PRACTICE OF MEDICINE.

Translated from the French of MM. Becquerel and Rodier. 8vo. cloth, reduced to 8*s.*

MR. A. B. SQUIRE, M.B.LOND.

COLOURED PHOTOGRAPHS OF SKIN DISEASES.

In Twelve Parts (one every month), with Letterpress, 3*s.* 6*d.* each.

No. I. PSORIASIS.	No. IV. SCABIES.	No. VII. LUPUS.
,, II. IMPETIGO.	,, V. CHLOASMA.	,, VIII. SYPHILIDE.
,, III. LICHEN.	,, VI. FAVUS.	,, IX. NÆVUS.

MR. PETER SQUIRE.

I.

A COMPANION TO THE BRITISH PHARMACOPÆIA.

Second Edition. 8vo. cloth, 8*s.* 6*d.*

II.

THE PHARMACOPÆIAS OF THIRTEEN OF THE LONDON HOSPITALS,

arranged in Groups for easy Reference and Comparison. 18mo. cloth, 3*s.* 6*d.*

DR. STEGGALL.

STUDENTS' BOOKS FOR EXAMINATION.

I.

A MEDICAL MANUAL FOR APOTHECARIES' HALL AND OTHER MEDICAL BOARDS.

Twelfth Edition. 12mo. cloth, 10*s.*

II.

A MANUAL FOR THE COLLEGE OF SURGEONS;

intended for the Use of Candidates for Examination and Practitioners. Second Edition. 12mo. cloth, 10*s.*

III.

GREGORY'S CONSPECTUS MEDICINÆ THEORETICÆ.

The First Part, containing the Original Text, with an Ordo Verborum, and Literal Translation. 12mo. cloth, 10*s.*

IV.

THE FIRST FOUR BOOKS OF CELSUS;

containing the Text, Ordo Verborum, and Translation. Second Edition. 12mo. cloth, 8*s.*

V.

FIRST LINES FOR CHEMISTS AND DRUGGISTS PREPARING FOR EXAMINATION AT THE PHARMACEUTICAL SOCIETY.

Second Edition. 18mo. cloth, 3*s.* 6*d.*

MR. STOWE, M.R.C.S.

A TOXICOLOGICAL CHART, exhibiting at one view the Symptoms, Treatment, and Mode of Detecting the various Poisons, Mineral, Vegetable, and Animal. To which are added, concise Directions for the Treatment of Suspended Animation. Twelfth Edition, revised. On Sheet, 2*s.*; mounted on Roller, 5*s.*

MR. FRANCIS SUTTON, F.C.S.

A SYSTEMATIC HANDBOOK OF VOLUMETRIC ANALYSIS; or, the Quantitative Estimation of Chemical Substances by Measure. With Engravings. Post 8vo. cloth, 7*s.* 6*d.*

DR. SWAYNE.

OBSTETRIC APHORISMS FOR THE USE OF STUDENTS COMMENCING MIDWIFERY PRACTICE. With Engravings on Wood. Third Edition. Fcap. 8vo. cloth, 3*s.* 6*d.*

MR. TAMPLIN, F.R.C.S.E.

LATERAL CURVATURE OF THE SPINE: its Causes, Nature, and Treatment. 8vo. cloth, 4*s.*

DR. ALEXANDER TAYLOR, F.R.S.E.

THE CLIMATE OF PAU; with a Description of the Watering Places of the Pyrenees, and of the Virtues of their respective Mineral Sources in Disease. Third Edition. Post 8vo. cloth, 7*s.*

DR. ALFRED S. TAYLOR, F.R.S.

I.

A MANUAL OF MEDICAL JURISPRUDENCE. Seventh Edition. Fcap. 8vo. cloth, 12*s.* 6*d.*

II.

ON POISONS, in relation to MEDICAL JURISPRUDENCE AND MEDICINE. Second Edition. Fcap. 8vo. cloth, 12*s.* 6*d.*

MR. TEALE.

ON AMPUTATION BY A LONG AND A SHORT RECTANGULAR FLAP. With Engravings on Wood. 8vo. cloth, 5*s.*

DR. THEOPHILUS THOMPSON, F.R.S.

CLINICAL LECTURES ON PULMONARY CONSUMPTION; with additional Chapters by E. Symes Thompson, M.D. With Plates. 8vo. cloth, 7*s.* 6*d.*

DR. THOMAS.

THE MODERN PRACTICE OF PHYSIC; exhibiting the Symptoms, Causes, Morbid Appearances, and Treatment of the Diseases of all Climates. Eleventh Edition. Revised by Algernon Frampton, M.D. 2 vols. 8vo. cloth, 28*s.*

MR. HENRY THOMPSON, F.R.C.S.

I.

STRICTURE OF THE URETHRA; its Pathology and Treatment. The Jacksonian Prize Essay for 1852. With Plates. Second Edition. 8vo. cloth, 10*s.*

II.

THE DISEASES OF THE PROSTATE; their Pathology and Treatment. Comprising a Dissertation "On the Healthy and Morbid Anatomy of the Prostate Gland;" being the Jacksonian Prize Essay for 1860. With Plates. Second Edition. 8vo. cloth, 10*s.*

III.

PRACTICAL LITHOTOMY AND LITHOTRITY; or, An Inquiry into the best Modes of removing Stone from the Bladder. With numerous Engravings, 8vo. cloth, 9*s.*

DR. THUDICHUM.

I.

A TREATISE ON THE PATHOLOGY OF THE URINE, Including a complete Guide to its Analysis. With Plates, 8vo. cloth, 14*s.*

II.

A TREATISE ON GALL STONES: their Chemistry, Pathology, and Treatment. With Coloured Plates. 8vo. cloth, 10*s.*

DR. TILT.

I.

ON UTERINE AND OVARIAN INFLAMMATION, AND ON THE PHYSIOLOGY AND DISEASES OF MENSTRUATION. Third Edition. 8vo. cloth, 12*s.*

II.

A HANDBOOK OF UTERINE THERAPEUTICS. Second Edition. Post 8vo. cloth, 6*s.*

III.

THE CHANGE OF LIFE IN HEALTH AND DISEASE: a Practical Treatise on the Nervous and other Affections incidental to Women at the Decline of Life. Second Edition. 8vo. cloth, 6*s.*

DR. GODWIN TIMMS.

CONSUMPTION: its True Nature and Successful Treatment. Crown 8vo. cloth, 10*s.*

DR. ROBERT B. TODD, F.R.S.

I.

CLINICAL LECTURES ON THE PRACTICE OF MEDICINE. *New Edition, in one Volume, Edited by* Dr. Beale, *8vo. cloth,* 18*s.*

II.

ON CERTAIN DISEASES OF THE URINARY ORGANS, AND ON DROPSIES. Fcap. 8vo. cloth, 6*s.*

MR. TOMES, F.R.S.

A MANUAL OF DENTAL SURGERY. With 208 Engravings on Wood. Fcap. 8vo. cloth, 12*s.* 6*d.*

MR. JOSEPH TOYNBEE, F.R.S., F.R.C.S.

THE DISEASES OF THE EAR: THEIR NATURE, DIAGNOSIS, AND TREATMENT. Illustrated with numerous Engravings on Wood. 8vo. cloth, 15*s.*

DR. TUNSTALL, M.D., M.R.C.P.

THE BATH WATERS: their Uses and Effects in the Cure and Relief of various Chronic Diseases. Third Edition. 8vo. cloth, 2*s.* 6*d.*

DR. TURNBULL.

I.

AN INQUIRY INTO THE CURABILITY OF CONSUMPTION, ITS PREVENTION, AND THE PROGRESS OF IMPROVEMENT IN THE TREATMENT. Third Edition. 8vo. cloth, 6*s.*

II.

A PRACTICAL TREATISE ON DISORDERS OF THE STOMACH with FERMENTATION; and on the Causes and Treatment of Indigestion, &c. 8vo. cloth, 6*s.*

DR. TWEEDIE, F.R.S.

CONTINUED FEVERS: THEIR DISTINCTIVE CHARACTERS, PATHOLOGY, AND TREATMENT. With Coloured Plates. 8vo. cloth, 12*s.*

VESTIGES OF THE NATURAL HISTORY OF CREATION. Eleventh Edition. Illustrated with 106 Engravings on Wood. 8vo. cloth, 7*s.* 6*d.*

DR. UNDERWOOD.

TREATISE ON THE DISEASES OF CHILDREN. Tenth Edition, with Additions and Corrections by HENRY DAVIES, M.D. 8vo. cloth, 15*s.*

DR. UNGER.

BOTANICAL LETTERS. Translated by Dr. B. PAUL. Numerous Woodcuts. Post 8vo., 2*s.* 6*d.*

MR. WADE, F.R.C.S.

STRICTURE OF THE URETHRA, ITS COMPLICATIONS AND EFFECTS; a Practical Treatise on the Nature and Treatment of those Affections. Fourth Edition. 8vo. cloth, 7*s.* 6*d.*

DR. WALKER, M.B.LOND.

ON DIPHTHERIA AND DIPHTHERITIC DISEASES. Fcap. 8vo. cloth, 3*s.*

DR. WALLER.

ELEMENTS OF PRACTICAL MIDWIFERY; or, Companion to the Lying-in Room. Fourth Edition, with Plates. Fcap. cloth, 4*s.* 6*d.*

MR. HAYNES WALTON, F.R.C.S.

SURGICAL DISEASES OF THE EYE. With Engravings on Wood. Second Edition. 8vo. cloth, 14*s.*

MR. WARING, M.D., F.L.S.

A MANUAL OF PRACTICAL THERAPEUTICS. Second Edition, Revised and Enlarged. Fcap. 8vo. cloth, 12*s.* 6*d.*

DR. WATERS, M.R.C.P.

I.

THE ANATOMY OF THE HUMAN LUNG. The Prize Essay to which the Fothergillian Gold Medal was awarded by the Medical Society of London. Post 8vo. cloth, 6*s.* 6*d.*

II.

RESEARCHES ON THE NATURE, PATHOLOGY, AND TREATMENT OF EMPHYSEMA OF THE LUNGS, AND ITS RELATIONS WITH OTHER DISEASES OF THE CHEST. With Engravings. 8vo. cloth, 5*s.*

DR. EBEN. WATSON, A.M.

ON THE TOPICAL MEDICATION OF THE LARYNX IN CERTAIN DISEASES OF THE RESPIRATORY AND VOCAL ORGANS. 8vo. cloth, 5*s.*

DR. ALLAN WEBB, F.R.C.S.L.

THE SURGEON'S READY RULES FOR OPERATIONS IN SURGERY. Royal 8vo. cloth, 10*s.* 6*d.*

DR. WEBER.

A CLINICAL HAND-BOOK OF AUSCULTATION AND PERCUSSION. Translated by JOHN COCKLE, M.D. 5*s.*

MR. SOELBERG WELLS, M.D., M.R.C.S.

ON LONG, SHORT, AND WEAK SIGHT, and their Treatment by the Scientific Use of Spectacles. Second Edition. With Plates. 8vo. cloth, 6*s*.

MR. T. SPENCER WELLS, F.R.C.S.

I.

DISEASES OF THE OVARIES: THEIR DIAGNOSIS AND TREATMENT. Vol. I. 8vo. cloth, 9*s*.

II.

PRACTICAL OBSERVATIONS ON GOUT AND ITS COMPLICATIONS, and on the Treatment of Joints Stiffened by Gouty Deposits. Foolscap 8vo. cloth, 5*s*.

III.

SCALE OF MEDICINES WITH WHICH MERCHANT VESSELS ARE TO BE FURNISHED, by command of the Privy Council for Trade; With Observations on the Means of Preserving the Health of Seamen, &c. &c. Seventh Thousand. Fcap. 8vo. cloth, 3*s*. 6*d*.

DR. WEST.

LECTURES ON THE DISEASES OF WOMEN. Third Edition. 8vo. cloth, 16*s*.

DR. UVEDALE WEST.

ILLUSTRATIONS OF PUERPERAL DISEASES. Second Edition, enlarged. Post 8vo. cloth, 5*s*.

MR. WHEELER.

HAND-BOOK OF ANATOMY FOR STUDENTS OF THE FINE ARTS. With Engravings on Wood. Fcap. 8vo., 2*s*. 6*d*.

DR. WHITEHEAD, F.R.C.S.

ON THE TRANSMISSION FROM PARENT TO OFFSPRING OF SOME FORMS OF DISEASE, AND OF MORBID TAINTS AND TENDENCIES. Second Edition. 8vo. cloth, 10*s*. 6*d*.

DR. WILLIAMS, F.R.S.

PRINCIPLES OF MEDICINE: An Elementary View of the Causes, Nature, Treatment, Diagnosis, and Prognosis, of Disease. With brief Remarks on Hygienics, or the Preservation of Health. The Third Edition. 8vo. cloth, 15*s*.

THE WIFE'S DOMAIN: the YOUNG COUPLE—the MOTHER—the NURSE—the NURSLING. Post 8vo. cloth, 3*s*. 6*d*.

DR. J. HUME WILLIAMS.

UNSOUNDNESS OF MIND, IN ITS MEDICAL AND LEGAL CONSIDERATIONS. 8vo. cloth, 7*s*. 6*d*.

DR. WILLIAMSON, SURGEON-MAJOR, 64TH REGIMENT.

I.

MILITARY SURGERY. With Plates. 8vo. cloth, 12*s*.

II.

NOTES ON THE WOUNDED FROM THE MUTINY IN INDIA: with a Description of the Preparations of Gunshot Injuries contained in the Museum at Fort Pitt. With Lithographic Plates. 8vo. cloth, 12*s*.

MR. ERASMUS WILSON, F.R.S.

I.

THE ANATOMIST'S VADE-MECUM: A SYSTEM OF HUMAN ANATOMY. With numerous Illustrations on Wood. Eighth Edition. Foolscap 8vo. cloth, 12*s.* 6*d.*

II.

DISEASES OF THE SKIN: A Practical and Theoretical Treatise on the DIAGNOSIS, PATHOLOGY, and TREATMENT OF CUTANEOUS DISEASES. Fifth Edition. 8vo. cloth, 16*s.*

THE SAME WORK; illustrated with finely executed Engravings on Steel, accurately coloured. 8vo. cloth, 34*s.*

III.

HEALTHY SKIN: A Treatise on the Management of the Skin and Hair in relation to Health. Sixth Edition. Foolscap 8vo. 2*s.* 6*d.*

IV.

PORTRAITS OF DISEASES OF THE SKIN. Folio. Fasciculi I. to XII., completing the Work. 20*s.* each. The Entire Work, half morocco, £13.

V.

THE STUDENT'S BOOK OF CUTANEOUS MEDICINE AND DISEASES OF THE SKIN. Part I. Post 8vo. cloth, 5*s.*

VI.

ON SYPHILIS, CONSTITUTIONAL AND HEREDITARY; AND ON SYPHILITIC ERUPTIONS. With Four Coloured Plates. 8vo. cloth, 16*s.*

VII.

A THREE WEEKS' SCAMPER THROUGH THE SPAS OF GERMANY AND BELGIUM, with an Appendix on the Nature and Uses of Mineral Waters. Post 8vo. cloth, 6*s.* 6*d.*

VIII.

THE EASTERN OR TURKISH BATH: its History, Revival in Britain, and Application to the Purposes of Health. Foolscap 8vo., 2*s.*

DR. G. C. WITTSTEIN.

PRACTICAL PHARMACEUTICAL CHEMISTRY: An Explanation of Chemical and Pharmaceutical Processes, with the Methods of Testing the Purity of the Preparations, deduced from Original Experiments. Translated from the Second German Edition, by STEPHEN DARBY. 18mo. cloth, 6*s.*

DR. HENRY G. WRIGHT.

HEADACHES; their Causes and their Cure. Third Edition. Fcap. 8vo. 2*s.* 6*d.*

DR. YEARSLEY, M.D., M.R.C.S.

I.

DEAFNESS PRACTICALLY ILLUSTRATED; being an Exposition as to the Causes and Treatment of Diseases of the Ear. Sixth Edition. 8vo. cloth, 6*s.*

II.

ON THE ENLARGED TONSIL AND ELONGATED UVULA, and other Morbid Conditions of the Throat. Seventh Edition. 8vo. cloth, 5*s.*

CHURCHILL'S SERIES OF MANUALS.

Fcap. 8vo. cloth, 12*s.* 6*d.* each.

"We here give Mr. Churchill public thanks for the positive benefit conferred on the Medical Profession, by the series of beautiful and cheap Manuals which bear his imprint."—*British and Foreign Medical Review.*

AGGREGATE SALE, 137,000 COPIES.

ANATOMY. With numerous Engravings. Eighth Edition. By ERASMUS WILSON, F.R.C.S., F.R.S.

BOTANY. With numerous Engravings. By ROBERT BENTLEY, F.L.S., Professor of Botany, King's College. and to the Pharmaceutical Society.

CHEMISTRY. With numerous Engravings. Ninth Edition. By GEORGE FOWNES, F.R.S., H. BENCE JONES, M.D., F.R.S., and A. W. HOFMANN, F.R.S.

DENTAL SURGERY. With numerous Engravings. By JOHN TOMES, F.R.S.

MATERIA MEDICA. With numerous Engravings. Fourth Edition. By J. FORBES ROYLE, M.D., F.R.S., and FREDERICK W. HEADLAND, M.D., F.L.S.

MEDICAL JURISPRUDENCE. Seventh Edition. By ALFRED SWAINE TAYLOR, M.D., F.R.S.

PRACTICE OF MEDICINE. Second Edition. By G. HILARO BARLOW, M.D., M.A.

The MICROSCOPE and its REVELATIONS. With numerous Plates and Engravings. Third Edition. By W. B. CARPENTER, M.D., F.R.S.

NATURAL PHILOSOPHY. With numerous Engravings. Fifth Edition. By GOLDING BIRD, M.D., M.A., F.R.S., and CHARLES BROOKE, M.B., M.A., F.R.S.

OBSTETRICS. With numerous Engravings. By W. TYLER SMITH, M.D., F.R.C.P.

OPHTHALMIC MEDICINE and SURGERY. With coloured Engravings on Steel, and Illustrations on Wood. Second Edition. By T. WHARTON JONES, F.R.C.S., F.R.S.

PATHOLOGICAL ANATOMY. With numerous Engravings. By C. HANDFIELD JONES, M.B., F.R.C.P., and E. H. SIEVEKING, M.D., F.R.C.P.

PHYSIOLOGY. With numerous Engravings. Fourth Edition. By WILLIAM B. CARPENTER, M.D., F.R.S.

POISONS. Second Edition. By ALFRED SWAINE TAYLOR, M.D., F.R.S.

PRACTICAL ANATOMY. With numerous Engravings. (10*s.* 6*d.*) By CHRISTOPHER HEATH, F.R.C.S.

PRACTICAL SURGERY. With numerous Engravings. Fourth Edition. By WILLIAM FERGUSSON, F.R.C.S.

THERAPEUTICS. Second Edition. By E. J. Waring, M.D., F.L.S.

Printed by W. BLANCHARD & SONS, 62, Millbank Street, Westminster.